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Efficiency in Public Procurement in Rural Road Projects of Nepal

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Abstract

Transport infrastructure is important for economic growth. In Nepal, about 20 percent of rural residents have to spend more than 3 hours to go to the nearest marketplace or agriculture center. Public procurement is an important policy instrument to use resources wisely and efficiently. This paper analyzes a series of policy questions, from procurement design to contract management and project quality assurance. The paper finds that the competition effect is significant. To enhance competition, bidding documents can be distributed free of charge on a website. The bid preparation period can be extended. Security issues are also found to be particularly important to avoid unnecessary cost overruns and project delays. Heavy rainfall and the bidders' low-balling strategy are identified as other factors of project delays. The quality of roads would deteriorate with not only security incidence but also time, precipitation and traffic volume.

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EFFICIENCY IN PUBLIC PROCUREMENT
IN RURAL ROAD PROJECTS OF NEPAL

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EXECUTIVE SUMMARY

Transport infrastructure is among the most important driving forces for economic growth. In Nepal, rural road accessibility remains a crucial challenge. The vast majority of rural residents had to spend more than 30 minutes to access to paved roads. Public procurement is an important policy instrument to use resources wisely and efficiently.

This paper addresses a series of policy challenges in public road procurement, from procurement planning to contract management and project quality assurance. Important, these issues are interrelated to each other. Therefore, the issues need to be addressed in concert. Using data collected from 155 rural road upgrading contracts in Nepal, five questions are addressed: How do bidders determine their bidding strategy, i.e., bid prices, in competitive bidding for rural road contracts? How do they decide whether to participate in the procurement market? What are the main determinants of efficiency in contracting road works? Why ex post contract amendments, such as cost overruns and delays, happen? Which factor is important to ensure the quality of roads delivered by the project?

Our main findings and policy implications are as follows:

1. Competition needs to be enhanced particularly in government owned projects.

Competition is the most important factor to bring down road procurement costs. The level of competition is clearly insufficient in some public tenders in Nepal. In particular in government owned projects, the average competition is about 4.5, unfavorably compared to an average of 7.3 in World Bank financed projects. Significant losses—possibly, $3 million—are estimated to be incurred by the lack of competition.

2. Wider distribution of tender information at cheaper costs increases competition as well as transparency and accountability.

To attract more interest and bidders, tender notices should be distributed widely and at low costs. This will bring down the cost of entry for firms. Public tenders can be advertized on national newspapers, rather than local ones. E-bidding or e-procurement can distribute tender information even more widely and in a timely manner. The findings are consistent with the recent initiative that the Nepal government has taken in its e-procurement strategy.

3. Longer bid preparation periods encourage bidder participation in public tenders.

As stipulated in the procurement guidelines, it is important to grant sufficient time for firms to prepare bids. By doing so, even inexperienced contractors are allowed to consider to participate in auctions, thereby intensifying competition in the market. Of particular note, the extension of the bid preparation period is a no-cost measure for procurers. In Nepal, some of the government owned projects had extremely short bid preparation periods. As an indicative

target, 30 days may have to be given for bid preparation. The cost savings could be $0.2 million in the total sample projects financed by DDCs.

4. *Procurement packaging is an important element to influence the firms' entry and bidding decisions*

The study shows that the competition increases with the size of contracts. Too small contracts are not profitable enough to encourage potential contractors to participate in competitive bidding. Particularly, the number of participants can be increased to about 7 bidders for small contracts with a length of 10 km or less, which are the majority of the rural road contracts in Nepal. Procurers should reexamine the way of contract packaging to take advantage of the competition effect.

5. *Local contractors' capabilities need to be fostered to enhance competition.*

Firm location does not matter to bid prices but influences the bidders' entry strategy. For projects far from the capital where many construction firms are located, a fewer firms would likely apply. In addition, local firms do not appear competitive enough, despite their potential advantages of proximity to the project location. Public procurement can be used to foster the local business capacities. However, the careful allocation of projects is necessary to maintain competitive pressure and transparency in the market.

6. *Security is great concern for not only procurement costs but also road management.*

Security issues would push up bid prices and discourage the market entry of potential firms. Both will end up with a heavy burden on the economy. In addition, security incidence would cause cost overruns and project delays. Unstable security would also hamper timely road maintenance required. As a result, the quality of roads would deteriorate quickly where security is not secured.

7. *Severe weather causes project delays.*

The government should be aware of the risk of project delays caused by weather conditions. It rains a lot in Nepal. Increased precipitation is likely to cause project delays, which often lead to cost overruns and fiscal inefficiency. Some flexibility may be needed in the road procurement planning and budget formulation in Nepal.

8. *Proper and solid project design and preparation help to avoid unnecessary contract amendments and improve efficiency in the whole project cycle.*

Proper project specifications are important to avoid unnecessary contract amendments and minimize the risk of contractors' opportunistic behavior. In particular, large projects must be prepared carefully. Cost overruns and project delays tend to occur in relatively large road works. To ensure the quality of works, quality assurance mechanisms, such as post-qualification review, need to be established in the procurement system.

9. Roads are deteriorating with time, traffic and precipitation, if not properly maintained.

The quality of roads would decline with the duration of use of roads, traffic volume and cumulative precipitation. In Nepal, the vast majority of roads would be rated to be "very uncomfortable" if they are used for more than one year without proper maintenance.

10. Capacity building for efficient road procurement is necessary at local level

Government effectiveness in making road contracts varies significantly across districts. The difference can be attributed partly to technical reasons, such as technical complexity of projects. But it is also because the government capacities may not be sufficient at the local level. Important, the lengthy contract award process is likely to result in significant project delays. Thus, it is critical to develop the procurement capability of local governments. In addition, efforts toward procurement efficiency may be needed in collaboration with donors. While about 30 days are required to award a road contract in DDC projects, it takes more than 3 months in World Bank financed projects.

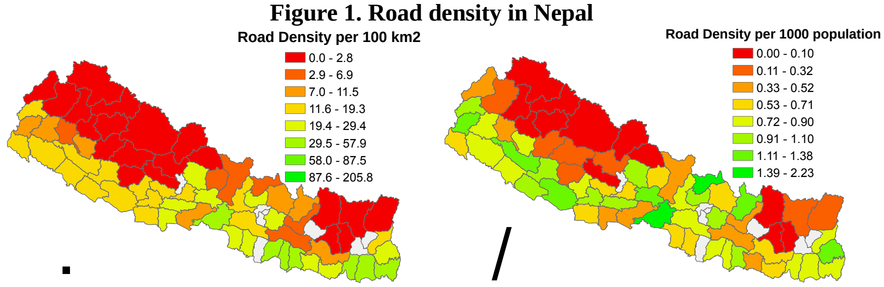
I. INTRODUCTION

Transport infrastructure is among the most important driving forces for economic growth. Sustained access to infrastructure is essential to improve living standards. In particular in rural areas, the lack of access to reliable transport infrastructure remains a significant constraint for people's daily life and local businesses in developing countries. About 900 million rural dwellers are estimated to have no access to all-weather road within two kilometers over the world.

In Nepal, rural road accessibility is one of the most crucial challenges. The vast majority of rural residents had to spend more than 30 minutes to access to paved roads. About one-third do not have paved road within more than 3 hours. The lack of access to all-season roads significantly limits their economic opportunities in remote areas. About 20 percent of rural residents have to spend more than 3 hours to go to the nearest marketplace or agriculture center. The road deficiency also has adverse effects on social welfare. Most urban people may find a health post within less than 30 minutes. However, for rural people, it often takes more than 1 hour (Nepal CBS, 2004).

In Nepal, road density remains low particularly in mountainous areas. On a per capita basis, road density is also low in northern and northeastern districts (Figure 1). In these regions, many rural roads were in operational condition only during the dry season. Road density looks relatively high around the capital, Kathmandu. However, with the significant concentration of population on the capital area taken into account, there may not be sufficient road network even in the capital area. In Terai, the road density per population is relatively high.

Figure 1. Road density in Nepal



Source: Central Bureau of Statistics, Nepal (2004).

Recognizing the issues in the transport sector, the government has been making efforts to improve the rural accessibility by upgrading dry-season-only roads to all-season standards and providing structures, gravel surface and Otta seal, which is a low-cost paving option (World Bank, 2005; 2007). Some of the impacts have already been observed. An interim survey of the project indicates that the people's mobility increased by more than 20 percent and that their travel time declined dramatically from 2.6 hours to 32 minutes on average (World Bank, 2009).

However, resources available for infrastructure development continue to be limited, as in other developing countries.[1] Nepal spent $105 million or 1.2 percent of GDP for road development (World Bank, 2005). This is more or less equally comparable with regional countries, such as Bangladesh spending 0.7 percent of GDP on transport infrastructure and India 1.4 percent. But these may still be far below the infrastructure needs, which are estimated at 3-7 percent of GDP in typical low-income countries.

Public procurement is an important instrument to use resources wisely and efficiently (e.g., Iimi, 2006; Estache and Iimi, 2011). "[T]he best way to find fiscal space for public investment is to eliminate waste and improve technical efficiency in public expenditure (World Bank, 2005)." However, how to design an efficient procurement system is still a challenging task, especially in the infrastructure sector. Infrastructure projects are often technically complex, highly customized and politically sensitive. As a result, competition for public contracts tends to be limited, and the procurement markets would likely be vulnerable

[1] See more discussion on transport infrastructure financing in Annex I.

to collusive bidding and corruption. The lengthy bid evaluation process is of particular concern. It will reduce transparency of the process and increase the risk of anticompetitive practices and cost overruns (Ware *et al*., 2007).

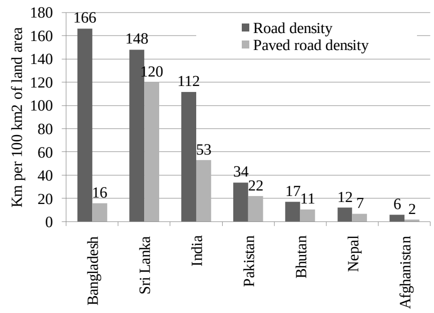
The current paper primarily aims at examining the firms' bidding and entry strategy to establish an efficient public road procurement system. However, it also casts light on a series of policy issues related to contract management and project quality assurance, because public contracts for infrastructure projects are often far from complete. In addition, firms can take the low-balling strategy—which is to submit an unrealistic bid and initiate renegotiation afterward (Ware and others, 2007). If this strategy cannot be excluded, the procurement performance needs to be analyzed along with assessment of ex post contract amendments as well as the quality of projects delivered.

The paper collected new data on procurement and contract performance from 155 rural road upgrading works in Nepal, on which about 820 bids were submitted. The quality of roads was also assessed by road specialists who visited every road location. The remaining paper is organized as follows: Section II describes recent road developments and other relevant issues in Nepal. Section III develops the empirical models with all possible hypotheses taken into account. The section also presents our data in an informal way. Section IV summarizes our formal empirical results, and Section V discusses policy implications. Then, Section VI concludes.

II. Recent Road Developments and Relevant Issues in Nepal

Nepal is one of the least developed countries in the world. About 29 million people live in the country, out of which half still live on less than $1.25 a day at 2005 international prices. Gross domestic product (GDP) per capita was about $430 in 2009. In the country, there exists some 17,000 km of road network. This is about 12 km per 100 sq. km of land area, which is compared unfavorably to other developing countries in the region. Not only quantity but also quality of roads has been low. About 40 percent of roads in Nepal remain to be paved (Figure 2).

Figure 2. Road density in South Asia



Note: Figures are the latest available data in 2002-2007.
Source: World Development Indicators.

In Nepal there are several important rural road reconstruction and rehabilitation projects assisted by multi- and bi-lateral donors. While the World Bank has been assisting the Rural Access Improvement and Decentralization Project (RAIDP) in 20 districts mainly in the Terai area, other donors, such as Asian Development Bank and UK Department for International Development (DfID), have been supporting other 45 districts under the Rural Reconstruction and Rehabilitation Sector Development Project. The remaining 10 districts are planned to be covered by scaling up the RAIDP.

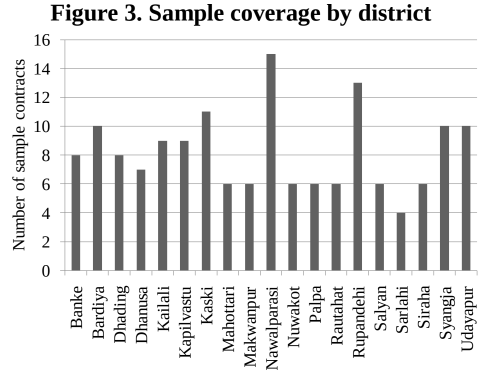
In the RAIDP, the 20 districts were selected according to the predetermined performance evaluation framework composed of a wide range of criteria, such as project preparedness, existing infrastructure gap and poverty profile. The framework aimed at creating institutional incentives to compete for resources among districts. The funding allocation was also designed on a performance basis. However, the original performance criteria were found unsuitable, given the prevailing conflict unstable political conditions, and low implementation capabilities at the district level. Therefore, the criteria were somewhat simplified, focusing on financial and physical progress of the works carried out.

Three entities share responsibility for the rural road development and maintenance in Nepal: the Ministry of Local Development (MOLD), the Department of Local Infrastructure and

Agricultural Roads (DOLIDAR), and individual District Development Committees (DDCs). DDCs are the main implementing agencies to prepare District Transport Management Plans, prioritize the local needs, mobilize community groups, and procure and manage civil works and services. However, the DDCs planning and implementation capacity remains weak. Thus, DOLIDAR is playing an important role in coordinating DDCs and providing technical and engineering support to them. MOLD is responsible for general oversight and monitoring of the whole program.

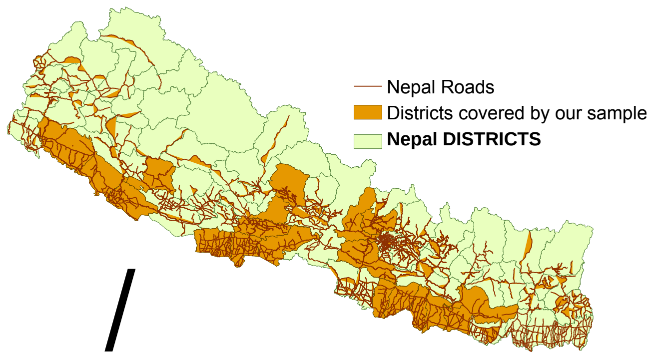
We collected procurement and contract data from 155 rural road upgrading works in 19 Terai districts assisted by the World Bank.[2] Data were also collected from projects financed by the government and other aid agencies. In each district, about 8 road contracts were reviewed—half from World Bank-financed projects and half from government-owned projects (Figure 3). Because of the selection criteria of the RAIDP, these districts have the relatively high road-sector development performance and thus high road density (Figure 4).

Figure 3. Sample coverage by district



[2] One of the 20 districts assisted by the RAIDP has not yet had road work contracts that can be evaluated at the time of our data collection.

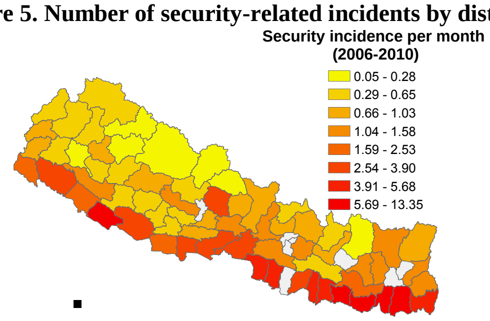
Figure 4. Existing road network and districts covered by our sample



Security is a matter of particular concern in Nepal. In particular in the Terai area where our data were collected, more security incidents were reported (Figure 5). According to the UN Nepal Security Database, about 200 security related incidents, such as abduction, attack and murder, happen nationwide every month (Figure 6). For public road procurement, intimidation or other threats could deter bidder participation. Local news has been reporting violence and intimidation against contractors placing bids. In our sample data, a project district is estimated to have experienced 3 incidents every month during the project implementation period. By construction, any measures to avoid conflicts and defend themselves would add to project costs and result in project delays.

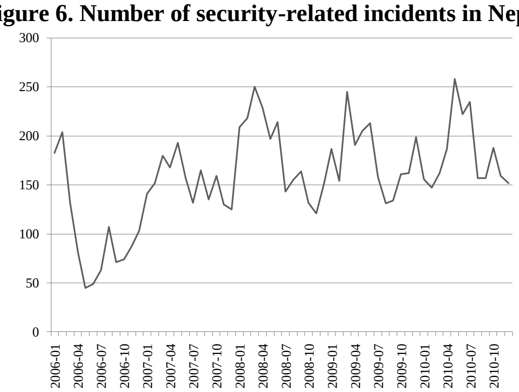
The country has been making efforts to improve the justice and security systems to promote rule of law and inclusive and equitable growth (United Nations, 2011). The government enacted the Procurement Act and Right To Information Act to improve procurement environment by legislation. However, it seems that there is still a long way to establish a sound and competitive marketplace for public procurement.

Figure 5. Number of security-related incidents by district



Source: UN Nepal Security Database.

Figure 6. Number of security-related incidents in Nepal



Source: UN Nepal Security Database.

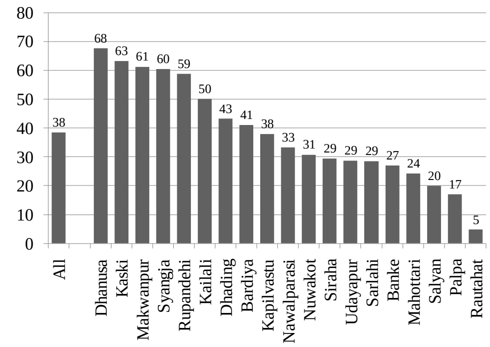
In general, governance matters to public procurement. In Nigeria, the majority of private firms surveyed on perceptions of public sector procurement reforms answered that they decided not to submit their expressions of interest in recent public tenders, because they did not trust the selection process. There is a general perception that contractors are predetermined or must pay a bribe. Particularly, integrity tends to be relatively weaker at the subnational levels (World Bank, 2008c).

In Nepal, ethnicity may be another issue that might affect the bidders' entry strategy in the market. In Nepal there are 103 castes and ethnic groups.[3] In some areas, a dominant ethnic group accounts for nearly half the population in a district. There is a general perception that

[3] In the 1991 census, there were 60 castes and ethnic groups in the country, some of which are re-categorized into new groups in the 2001 census.

ethnicity might be a barrier to entry in the public procurement market. In our sample, about 40 percent of bidders come from the districts where the dominant ethnic group is the same. The ethnicity barriers look high in certain districts (Figure 7).[4]

Figure 7. Share of bidders that come from districts with the same dominant ethnicity as project areas (percent)



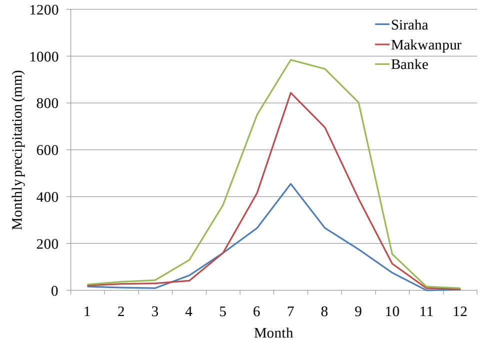
Weather may be another important determinant of road procurement and contract performance in Napal. Some of the selected districts have much precipitation, particularly in summer (Figure 8). In our sample districts, the average monthly precipitation over the past 10 years was about 200 mm per a month. The average monthly precipitation was relatively low in Banke and Kaski. But the precipitation exceeded 300 mm per month in Banke and Nuwakot (Figure 9). [5]

Precipitation has two implications in our context. First, heavy rains and storms will interrupt civil works, causing project delays and cost overruns. Second, precipitation can have an implication to the quality of roads. Particularly, unpaved or gravel roads are vulnerable to precipitation. The quality roads would deteriorate with precipitation if roads are not well maintained.

[4] For instance, 47 percent of district population in Makwanpur is Tamang people. 30 out of 49 bidders who applied for road projects in the district were local—registered in Makwanpur—or come from other districts where the dominant ethnic group is also Tamang, such as Dhading and Nuwakot.

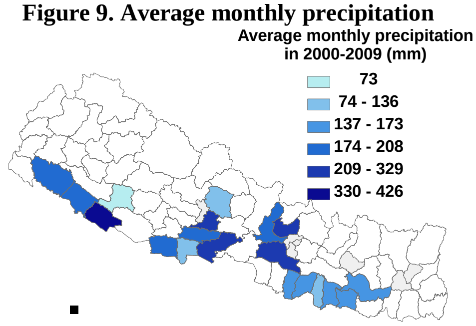
[5] Our monthly precipitation data are based on 20 weather stations that are close to our surveyed roads. Thus, the precipitation variables that we use in this paper are district-specific but time-variant and thus contract-specific.

Figure 8. Average monthly precipitation for the past 10 years



Source: Authors' calculation based on data from the Ministry of Environment, Nepal.

Figure 9. Average monthly precipitation



Given these backgrounds, road procurement costs vary significantly across districts, though the absolute levels remain low by global standards. The average unit cost of road upgrading is about NRs1.6 million or $23,000 per km (Table 1), which is far below the range of unit costs supported by the literature.[6] This is mainly because of the project specifications. Our sampled roads are mostly unpaved, gravel roads with simple surface treatment, if any. If an additional surface material, such as otta seals, is added, the project cost increases by $3,000-4,000 per km. Still, it is relatively cheap.

Normalized bids, which are bid prices relative to engineering cost estimates, vary from 0.55 in Dhanusa to 1.05 in Syangja (Figure 10). Normalized bids are a good indicator to incorporate unobserved heterogeneity in road specifications. The average normalized bid is

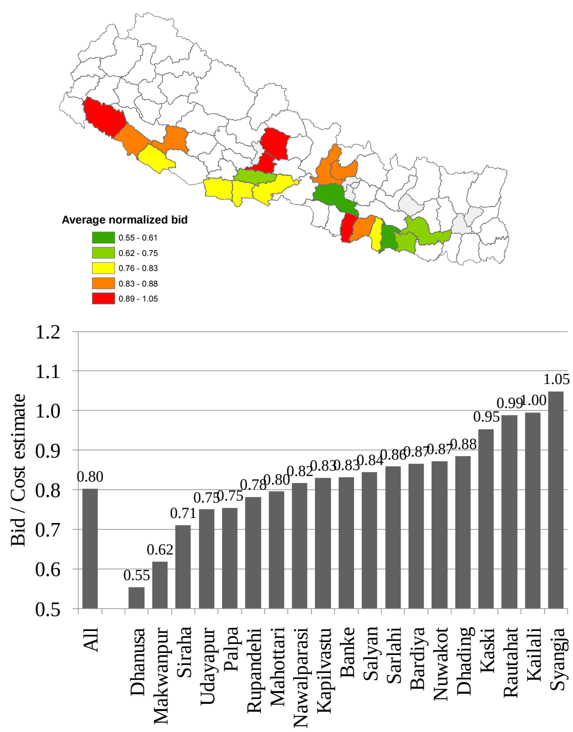
[6] An estimate of unit cost is about $410,000 per km (Fay and Yepes, 2003). Another is $390,000 for rehabilitation and $360,000 for upgrading in Africa (Alexeeva, Padam and Queiroz, 2008). Foster and Briceno-Garmendia (2010) also estimate the road rehabilitation cost at $200,000 to $500,000 per km, depending on country and the scale of roads.

about 0.8, which means that the government's engineering cost estimates are reasonable but tend to slightly overestimate the true costs. The question is why some districts are spending twice as high normalized costs as others. This paper will explore reasons.

Table 1. Average rural road contract and unit costs in Nepal

	Obs	Mean	Std. Dev.	Min	Max
Actual payment per contract (million rupee)	156	7.76	7.95	0.14	39.89
Actual payment per km (million rupee)	156	1.63	2.32	0.02	21.97

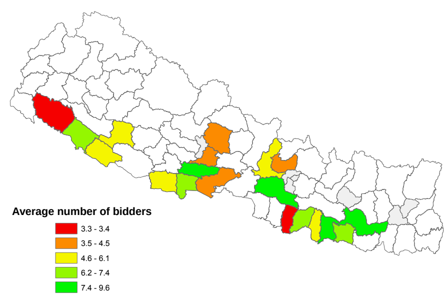
Figure 10. Average normalized bid by district



Lack of competition may be one of the alleged concerns. The average number of bidders that participated in competitive bidding is about 6. This appears consistent with the existing literature. For highway construction auctions in Florida, the number of bidders ranged from 2 to 19, with an average of about 5 (Gupta, 2002). In Oklahoma, the average number of bidders is 3.3 (De Silva, Dunne, and Kosmopoulou, 2003). In Africa, road auctions have an average of 5 firms with a range of between 1 and 15. Most have 3 or 4 bidders (Alexeeva, Padam, and Queiroz, 2008).

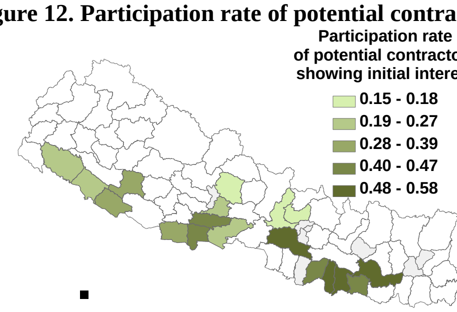
In Nepal the level of competition varies considerably across regions. The average number of bidders was only about 3 in Kailali and Rautahat. But competitive bidding in Dhanusa attracted more than 9 firms on average (Figure 11). There is some broad consistency between the level of competition and realized procurement costs. Where competition is limited, normalized bids tend to be high.

Figure 11. Average number of bidders by district



Potential entrants do exist in the country, but they may be located unevenly across regions. If firms that bought the bidding documents but decided not to submit bids are considered as potential contractors, there are a number of prospective bidders particularly in the north of Kathmandu and Western districts, such as Kailali and Bardiya. In these districts, only 2-3 out of 10 potential contractors that bought the bidding documents submitted bids (Figure 12).

Figure 12. Participation rate of potential contractors

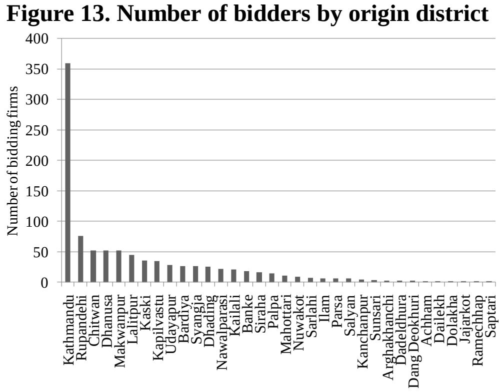


There are many possible reasons why these prospective firms did not enter the market. On the physical side, firm location may matter (e.g., Porter and Zona, 1993; Price, 2008). There are two potential implications. First, the entry costs may be high for firms located far from a project site. They may not be familiar with local conditions around the site. They may not be acquainted with potential contenders in the local market. Therefore, they may have to incur more costs to prepare their bids. This can result in limiting the bidder participation.

Second, the cost of undertaking a project may also be high for those who are located far from the project site. They may not have transaction with good local material suppliers. Supervising the work from a distant place is generally more costly, because of higher transportation and travel costs. It is usually costly to transport road work equipment, such as paver, across regions, especially in the mountainous areas. In addition, skill and equipment sets required may be different across regions; thus, applying for contracts in distant places may add to production costs. This will be reflected in bid prices. Otherwise, firms may simply decide not to enter the market.

In our data, a large number of bidders come from the nation's capital, Kathmandu, and its neighboring districts in the south (Figure 13). Fewer contractors may be willing to undertake road works in distant places from Kathmandu. In such cases, contract prices may be high, because of high transaction and mobilization costs of firms.

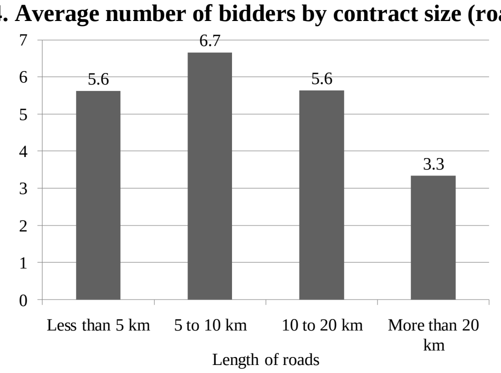
Figure 13. Number of bidders by origin district



Procurement planning is also an important element influencing the firms' entry and bidding decisions. In Nepal, most contracts assisted by the World Bank and other donors are fairly small. How to (un)bundle project components is an important policy question to encourage or discourage the bidder participation (Grimm and others, 2006). In theory, on one hand, smaller contracts may attract more contractors that are relatively small yet specialized. On the other hand, dividing a project into smaller contracts will sacrifice potential economies of scale in procurement and production.

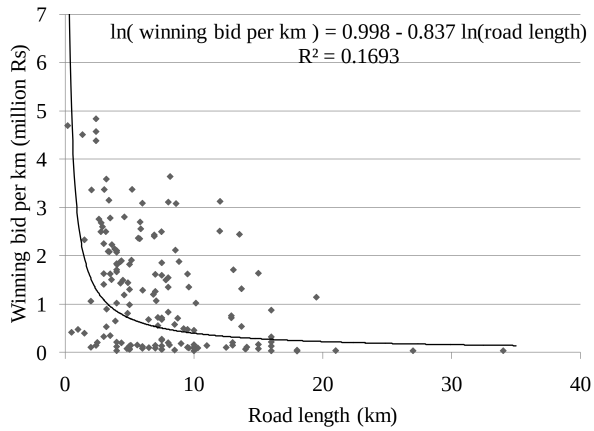
There exists a rule of thumb for how to divide tasks, but significant flexibility in procurement planning is left to procurers.[7] Our sample data show the mixed relationship between the size of contracts and the number of bidders. For relatively small contracts, participants increased in number with the size of contracts (Figure 14). This may be because small contracts are too costly for firms to undertake, given their high transaction and mobilization costs for small contracts. In addition, economies of scale exist in procurement (Figure 15).[8] As a result, the unit costs of road procurement tend to be high for small contracts, as shown in the case of Africa (e.g., Foster and Briceno-Garmendia, 2010).[9] But the number of participants may decline when the length of contracted roads increases further. Thus, more formal analysis is needed to investigate this tradeoff between the competition effect and economies of scale in procurement.

Figure 14. Average number of bidders by contract size (road length)



[7] The World Bank's current procurement guidelines stipulate that "[t]he size and scope of individual contracts will depend on the magnitude, nature, and location of the project. For projects requiring a variety of goods and works, separate contracts generally are awarded for the supply and/or installation of different items of equipment and plant."
[8] Some of the statistical outliers are omitted, such as 2 observations with unit bid prices greater than NRs7.9 million.
[9] A construction work of a more than 50 km road would cost $290,000 per km, but it would be $400,000 if it is less than 50 km (Foster and Briceno-Garmendia, 2010).

Figure 15. Contract size and winning bid per km



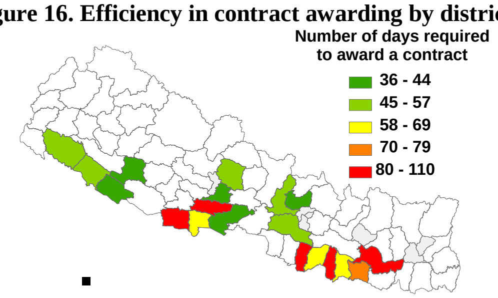
Efficiency in road contracting in Nepal may be favorably compared to other low-income countries, especially in Africa, where the average time required to award a contract after the bid opening ranges from 2-3 months to nearly a year (Table 2). In Nepal, the bid evaluation takes on average about 65 days. But it varies across districts, ranging from 30 days in Nawalparasi and Nuwakot to 100 days in Mahottari, Palpa and Rautahat (Figure 16). The difference may depend on technical conditions, such as the complexity of works, and the number of bids to be assessed. But the lengthy evaluation process is clearly a matter of concern, because it would inflate the procurement costs and reduce the transparency of the process.

Table 2. Average time required to sign a road contract after the bid opening in low-income countries in Africa

	Avg. time (days)
Congo, Democratic Rep. of	71.2
Madagascar	88.8
Ghana	153.1
Zambia	187.9
Ethiopia	207.4
Mozambique	220.6
Tanzania	253.7
Malawi	261.5
Uganda	326.3
Kenya	348.0

Source: Alexeeva, Padam, and Queiroz, 2008.

Figure 16. Efficiency in contract awarding by district



In Nepal, ex post contract adjustments appear relatively moderate in financial terms, but many projects incurred significant delays. Infrastructure contracts are often far from complete and experience massive cost overruns and project delays. About 30 percent of PPP infrastructure transactions underwent renegotiation within two years after being awarded (Guasch, 2004). Some adjustments are necessary because of unanticipated technical difficulties, but others may be caused by the firms' opportunistic low-balling strategy (Ware and others, 2007). In the transport sector, 9 out of 10 projects experienced cost overruns (Flyvbjerg and others, 2002). Project delays also add to cost overruns. Each year of delay would add on average $4.6 million to a project cost of $100 million in the transport sector (Flyvbjerg *et al*., 2004).

In our sample, the road projects experienced considerable delays, but cost overruns were relatively small. Road contracts experienced a delay of 104 days on average. About 10 percent of projects experienced more than 1 year of delay (Figure 17). About 45 percent of contracts incurred cost overruns, which range from several percent to 20 percent of the original contract amounts. About 20 contracts experienced cost underruns, mostly because the scope of the work was reduced (Figure 18). Since our sample projects are relatively simple rural road rehabilitation works, unexpected geotechnical issues are unlikely to cause cost overruns. The low-balling strategy may also be difficult, because there may be little room to justify cost adjustments due to technical reasons.

But projects can be delayed for several reasons. Civil works may be delayed by heavy rain at the project sites, as discussed above. Another possibility is the low-balling strategy counting on ex post project delays. Firms can propose an unrealistic schedule and then diminish their efforts to accomplish a work on schedule, causing delays.

Figure 17. Project delays (number of days)

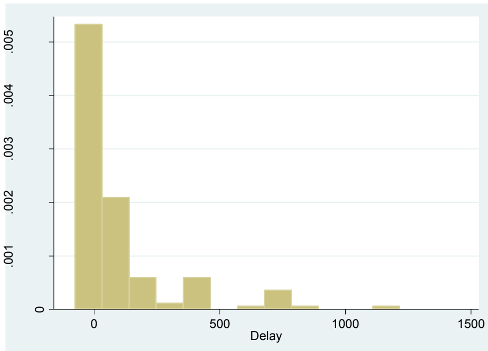
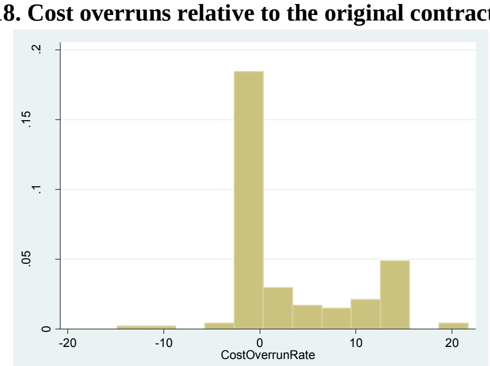
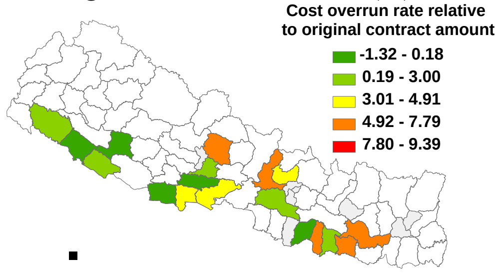


Figure 18. Cost overruns relative to the original contract amount



The contract performance differs across districts (Figure 19). Some districts are better at managing road contracts than others. The average cost overrun rates are 7 to 9 percent in Rautahat, Mahottari and Udayapur. But other districts, such as Banke and Kailali, have very small cost overruns less than 3 percent. The difference may be able to be explained for both internal and external reasons. On one hand, the government effectiveness may be different at the local level. The implementation capacities of district-level executing agencies, DDCs, are relatively high in our sampled districts. Still, their capabilities of managing and supervising contracted works may differ. On the other hand, weather and security issues are external factors that may affect the contract performance. These are generally beyond the capabilities of DDCs to manage contracts.

Figure 19. Cost overruns rate (%)

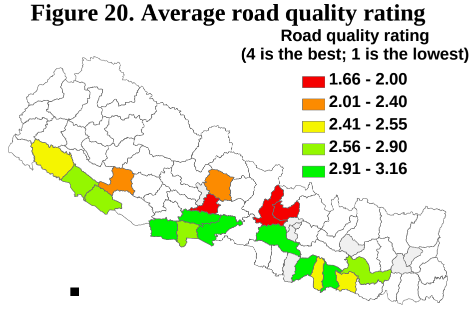


Finally, the quality of roads that were upgraded and have been used differs across districts. We classified road conditions into four categories: (i) very uncomfortable, (ii) uncomfortable, (iii) fairly comfortable, and (iv) very comfortable (Table 3). This is a subjective rating but based on the field survey. Transport specialists actually drove on each road and evaluated the quality of roads. Despite our small sample size (per district), there is a clear trend: The quality of roads is relatively low around the nation's capital, possibly because of the large traffic volume, weather conditions and other institutional factors (Figure 20).

Table 3. Road quality rating criteria

Rating	Condition
4	Very comfortable throughout the entire road segment
3	Fairly comfortable though occasionally jolting
2	Uncomfortable with frequent shakes
1	Very uncomfortable with continuous shakes and frequent slowdown and stops

Figure 20. Average road quality rating



III. Empirical Models and Data

Bid equation

To formally investigate the bidding behavior in the road procurement market, the following symmetric equilibrium bid function is considered based on the empirical auction literature (e.g., Porter and Zona, 1993; Gupta, 2002; Estache and Iimi, 2009, 2010):

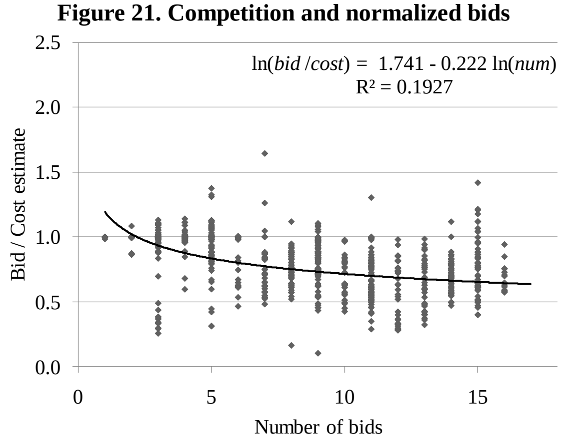
$$\ln bid_{it} = \alpha_1 \ln num_t + \alpha_2 \ln secritybefore_t + X'_t \beta \\ + \alpha_3 \ln dist_{it} + \alpha_4 D(ethinicity_{it}) + W'_i \gamma + \varepsilon_{it} \tag{1}$$

where bid_{it} is the amount of evaluated bid—both winning and losing— submitted by bidder *i* on road contract *t*. In the first-price sealed-bid format, both winning and losing bids are equally informative to estimate the equilibrium bid. *num* is the number of bidders who participated in the auction.

The functional form is consistent with both auction theory and the existing empirical auction literature to capture the competition effect associated with *num*. In theory, the bidding strategy depends on the level of competition (e.g., Wilson, 1977; Milgrom and Weber, 1982; Wolfstetter, 1996). Under the standard setting, bids are expected to approach the lowest possible market price, as the number of bidders increases. This is because the probability that a bidder wins a contract with a given bid price would decline, as the number of participants increases. Under a certain distributional assumption for the private costs, the competition effect would diminish in a convex fashion, as the number of bidders increases. On the empirical side, auctions have been supportive of the competition effect and the effect tapers off quickly as the number of bidders grows. This is why many empirical auction papers model the effect under the logarithmic specification (e.g., Kessel, 1971; Brannman and others, 1987; Paarsch, 1992; Iimi, 2006). As per Rezende (2005), the mapping between winning bids and the number of bidders is never linear.

At first glance, our sample data also seem to support the fact that competitive pressure exists in the road procurement market of Nepal. Although the level of competition is still low, the bids relative to engineering cost estimates tend to decline, as the competition increases (Figure 21). Of course, however, this is merely on a simple correlation basis; the competition effect has to be tested formally by estimating Equation (1).

Figure 21. Competition and normalized bids



To capture the impact of security issues, *securitybefore* is included, which is defined by the number of security-related incidents in a project host district during the three months prior to the auction. Note that this is constructed based on the information of incidents before each auction. This is the best information that potential bidders can know and incorporate in their bid calculation. Based on the past history of security incidents, they are assumed to estimate the likelihood of similar future incidents.

X controls for other contract-specific technical characteristics, such as engineering cost estimates, length of roads, width of the road, thickness of the surface, and used materials (see Table 4 for details).[10] Note that the engineering cost estimate, which is calculated by DDCs prior to public tendering, is included in *X* to control the observable and unobservable size

[10] A small but positive value is used to avoid logarithms of zero in independent variables, if they are zero.

effect of contracts.[11] *X* also includes a binary variable to indicate whether an auction includes the ex post quality evaluation process to exclude technically unreliable bids. About 90 percent of our sampled auctions adopted this mechanism. To control other district-level unobservables, we include 18 dummy variables to indicate project districts.

To account for heterogeneity across bidders, we include the distance—denoted by *dist*—between a project site and a contractor's location, which is calculated as a straight line distance between the two district capitals. This is merely an approximation; it is not the exact distance that individual contractors would have to go and work if awarded. Intuitively, it would be more costly to supervise any public work from a distant location. In addition, as discussed, ethnicity may be one important factor determining the bidding strategy in Nepal. *D*(*ethnicity*) is set to one if the dominant ethnicity is the same between a project host district and a bidder's home district. Dummy variables indicating bidders' origin districts are also included in *W*. Firms may have unobserved comparative advantages. Local firms may have the cost and information advantage to supervise a project. Firms outside the district may have more work experience and stronger financial background.

Table 4. Summary statistics

Variable	Abbreviation	Obs	Mean	Std. Dev.	Min	Max
Bid equation:						
Evaluated bid amount (NRs million)	*bid*	599	13.70	70.90	0.27	1410.00
Number of bidders	*num*	106	5.86	4.04	1	15
Number of security incidents during the three months prior to each tender	*securitybefore*	106	10.95	10.21	0	38
Line distance between project and firm origin districts	*dist*	599	121.74	159.28	0	762.57
Dummy for the same dominant ethnicity between project and firm origin districts	D(*ethnicity*)	599	0.48	0.50	0	1
Engineering cost estimate (NRs million)	*cost*	106	9.22	9.80	0.32	39.40
Length of roads (km)	*length*	106	8.64	5.44	0.20	34.00
Number of lanes	*lane*	106	1.05	0.21	1	2
Thickness of road surface (mm)	*thickness*	106	7.11	9.33	0	50
Gravel (m3)	*gravel*	106	2279.6	2900.4	0	18600.0

[11] An alternative is to regress the normalized bid on contract characteristics. However, our model is considered more flexible, since this alternative specification assumes that the coefficient of the engineering cost estimate is equal to one, which is not necessarily the case in general.

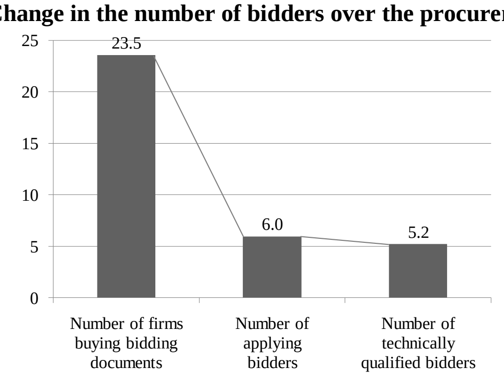
Bitumen (kg)	*bitumen*	106	4762.4	14122.5	0	79029.6
Earthworks (m3)	*earth*	106	6742.0	12665.7	0	93403.0
Brickworks (m3)	*brick*	106	45.2	165.5	0	1204.1
Gabion (m3)	*gabion*	106	238.6	856.4	0	8400.0
Excavation (m3)	*excavation*	106	2952.1	5319.8	0	29266.6
Cement concrete (m3)	*cement*	106	32.7	74.5	0	507.8
Dummy variable for postqualification of bids	D(*postqualify*)	106	0.92	0.28	0	1
Bidder participation:						
Number of bidders purchasing bidding documents	*bdnum*	118	22.53	17.93	4	107
Price of bidding documents	*bdcost*	118	1547.6	1044.6	290.5	3576.1
Bid preparation period (days)	*bdpreptime*	118	25.94	9.25	6	52
Efficiency in contract awarding:						
Number of days required to award a contract	*dayscontracting*	154	64.66	47.46	1	190
Contract management:						
Cost overrun rate (percent)	*overrun*	155	3.73	6.25	-14.83	21.69
Project delay (days)	*delay*	152	107.25	208.09	-76	1217
Number of security incidents during the project implementation	*securityduring*	152	33.86	47.06	0	280
Precipitation during the project implementation (mm)	*rainduring*	155	1652.22	1724.13	0	8774.2
Difference between the winning bid and the second lowest bid (NRs million)	*lowball*	142	-0.32	2.70	-29.60	6.29
Project quality:						
Confortability rating (1 to 4)	*rate*	136	2.63	0.60	1	4
Average traffic speed (km per houir)	*speed*	148	24.71	10.13	7.50	57.00
Number of days for which a road has been used since the project completion	*age*	136	794.32	497.60	11	2656
Cumulative traffice since the project completion	*traffic*	132	150802	153255	0	807884
Number of security incidents after the project completion	*securityafter*	133	81.94	79.05	0	377
Precipitation after the project implementation (mm)	*rainafter*	136	4953.4	3591.9	0.0	18223.2

Bidder participation

One of the most important empirical issues in estimating Equation (1) is that the number of bidders, *num*, is likely to be endogenous. Basic auction theory assumes it fixed. In reality, however, contractors may or may not enter the market for many reasons. Endogenous auction theory suggests that the entry cost would determine how many bidders would participate in an auction. If a fixed positive cost is required for participating in an auction, bidders will enter until their expected profits are driven to the entry cost. At this level no more firms can expect nonnegative profits from new entry. Therefore, the bidder participation can be increased by reducing the entry costs or by raising the profit guaranteed to the least efficient bidder in the procurement market (McAfee and McMillan, 1987; Levin and Smith, 1994; Menezes and Monteiro, 2000).

In practice, the bidder participation is a dynamic process. Some firms may decide not to enter the market, even though having shown initial interest. Other contractors may be disqualified for technical reasons, even if they wanted to participate in the competition. Our sample data show that the vast majority of firms in Nepal are giving up the opportunity to participate in public tenders and engage in public works. At the initial stage, about 23 firms on average bought the bidding documents; but only 6 firms applied to the formal process. After the technical evaluation, 5 bids were compared for determining the winner (Figure 22).

Figure 22. Change in the number of bidders over the procurement process



The question is why they decided not to apply for public tenders, though showing initial interest. To address this bidder participation problem, the following entry equation is considered:

$$num_t = f(securitybefore_t, X_t, Z_t) \tag{2}$$

Equation (2) can be estimated by a generalized count regression model, i.e., zero-truncated negative binomial model, because the observed number of bidders *num* is a positive integer and typical of count data (e.g., Li and Perrigne, 2003; Li and Zheng, 2006; Ohashi, 2009). The bidder participation is assumed to depend on security conditions, auction design, contract size, and other project-specific technical characteristics in *X*. As discussed, the impact of security issues is of particular concern in Nepal. Aggravating security might be discouraging firms from applying for public tenders. *Z* is a vector of instrument variables that particularly affect the firms' entry decisions. The equation can also be estimated as a first stage regression, when the bid function is estimated with the number of bidders instrumented directly by *Z*.

Another approach to estimate the bidders' entry strategy is a binary probability model where each bidder's decision about whether to apply for a public tender is regressed on explanatory variables. Letting a binary variable, $entry_{it}$, be 1 if bidder *i* participates in auction *t* and zero otherwise, the probability of bidder *i*'s participating in auction *t* is:

$$\begin{aligned} \Pr(entry_{it}=1) &= \Phi(securitybefore_t, dist_{it}, D(ethnicity_{it}), X_t, W_i, Z_t) \\ \Pr(entry_{it}=0) &= 1-\Phi(securitybefore_t, dist_{it}, D(ethnicity_{it}), X_t, W_i, Z_t) \end{aligned} \tag{3}$$

In this case, bidder-specific characteristics, such as *dist* and *ethnicity*, can be incorporated in the model.

Following the endogenous auction literature, three instruments are considered for *Z*: (i) the number of prospective contractors who can potentially apply for each tender, (ii) costs of bidding documents, and (iii) the length of bid preparation periods.

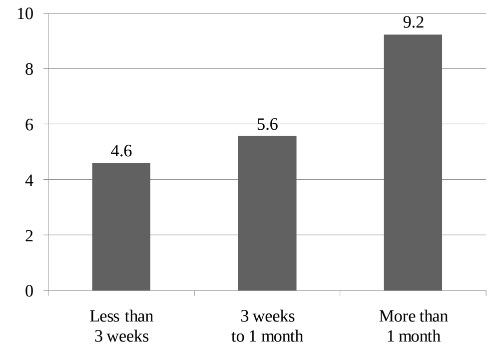
The first instrument is the number of firms who bought the bidding documents (denoted by *bdnum*). This is considered as the maximum number of contenders that could participate in each auction. The underlying idea is the same as the use of the number of plan holders or eligible bidders in the existing literature (e.g., Haile, 2001; Paarsch, 2007; De Silva, Dunne, Knkanamge & Kosmopoulou, 2008). In our case, the number of firms requesting the bidding documents or applying for the prequalification is determined prior to the submission of bids. As shown in Figure 20, some firms may not apply, and others may be disqualified. But the number of firms purchasing the bidding documents can be a good proxy of the potential pool of bidders.

Second, the price of bidding documents (denoted by *bdcost*) is included in *Z*. Theory suggests that potential firms may not participate in public tenders, because there are some implicit and/or explicit costs of entry. The cost of bidding documents may not be economically significant but surely adds to the entry costs. In Nepal, bidding documents cost NRs300 to NRs3,500 with an average of NRs1,800 or $25 in our sample.

Finally, the number of days granted contractors to prepare bids (denoted by *bidpreptime*) is included in *Z*. The longer bid preparation period can reduce the entry costs for potential contractors, particularly inexperienced firms. In addition, one of the yellow flags that may signal corruption or collusion is that an invitation to bid is published just a few days or a few weeks before bids have to be submitted (Ware *et al.*, 2007). The World Bank Procurement Guidelines stipulate "[g]enerally, not less than 6 (six) weeks from the date of the invitation to bid or the date of availability of bidding documents, whichever is later, shall be allowed for ICB. Where large works or complex items of equipment are involved, this period shall generally be not less than 12 (twelve) weeks to enable prospective bidders to conduct investigations before submitting their bids."[12] Our data seem to be supportive of the view that the too short time for the bid preparation could restrain the bidder participation (Figure 23).

[12] The World Bank's *Guidelines: Procurement under IBRD Loans and IDA Credits*, Clause 2.44 (pp. 21).

Figure 23. Average number of bidders by duration of bid preparation



Efficiency in contracting

One of the possible disadvantages of attracting more bids is that the administrative cost of procurers would increase with the number of applicants. Technical complexity in public works may also add to the time required to evaluate bidders and bids. However, the lengthy procurement process tends to lack transparency and raise procurement costs. Inefficient contracting would also lead to ex post adjustments, because of inflated input prices during the lengthy process.

To measure the administrative efficiency in contracting, the following equation is considered:

$$\ln dayscontracting_t = \alpha_1 \ln num_t + \alpha_2 \ln securitybefore + X'_t \beta \qquad (4)$$

where *dayscontracting* is defined by the number of days required to award a contract after the bid opening date. In Nepal, the time required to evaluate bids and award (or sign) a contract seems to increase proportionally with the number of bids received. On a simple correlation basis, one additional bid might add 12 days on average to the evaluation period (Figure 24).

Contrary to our prior expectation, the time for the bid evaluation seems to proportionally decrease, not increase, with the size of contracts (Figure 25). Smaller contracts require more time to be awarded. This may raise concern about governance in public procurement and political interference, because there is a view that smaller contracts are often prepared using weaker, less formal, and less transparent procedures than those used for large contracts. As a result, the stakeholders involved have difficulty disputing formally, and this motivates corruption among both public officials and private contractors (World Bank, 2008a). If this is the case, it takes longer to negotiate with the lowest evaluated bidder and award a contract for smaller works.

Related to the above, security-related incidents, such as intimidations and complaints, may retard the bid evaluation process. Note that our security variable, *securitybefore*, is an approximation, since there is no available data representing the actual incidence that is specifically related to the public road procurement. But our security proxy is expected to capture unobserved obstructions through the bid evaluation procedures.

Figure 24. Average time between the bid opening and the contract award by level of competition

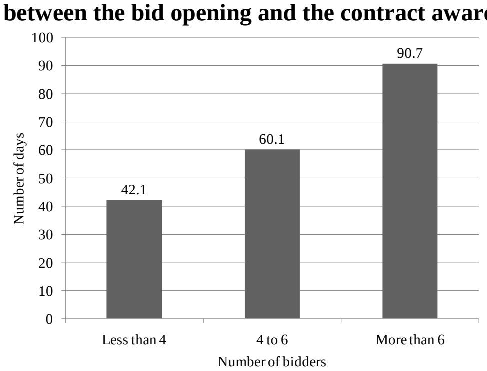
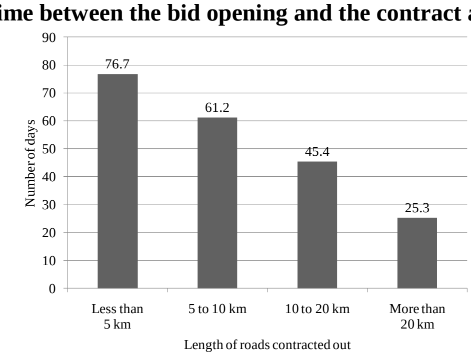


Figure 25. Average time between the bid opening and the contract award by contract size



Contract management

Good procurement and efficient contracting are necessary but may not be sufficient to ensure the delivery of quality services as originally planned. Many infrastructure projects in fact incur massive cost overruns and project delays. To examine why these post-award adjustments happened, the following equation is examined:

$$
\begin{aligned}
Y_t = {} & \alpha_1 \ln securityduring_t + \alpha_2 \ln rainduring_t + \alpha_3 \ln num_t + \ln \alpha_4 \ln lowball_t \\
& + \alpha_5 \ln dayscontracting_t + X'_t \beta + \varepsilon_t
\end{aligned}
\qquad (5)
$$

where Y is a measurement of ex post adjustments, for which we use two variables: the rate of cost overruns relative to the original contract amount (denoted by *overrun*) and the number of days by which a project delayed (denoted by *delay*).

Ex post adjustments depend on technical factors. For instance, ex post adjustments are likely to happen if contracts are technically complex and involve greater project risks. This will be captured by X in Equation (5). In Nepal, larger-size contracts seem to have more significant cost overruns. Cost overruns were minimal if the contract amount is less than NRs5 million or $70,000. Beyond that level, significant cost overruns are likely to occur (Figure 26). Similarly, larger contracts seem to be more likely to be delayed. The projects, of which the contract values exceed NRs5 million, delayed by 100-250 days on average (Figure 27).

Figure 26. Cost overruns and size of contracts

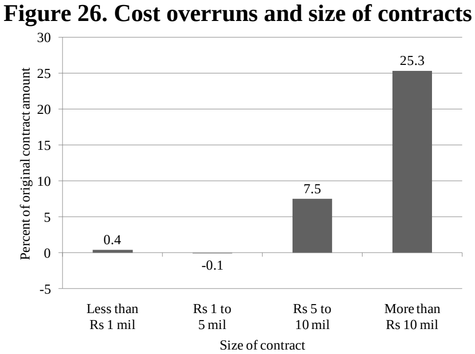
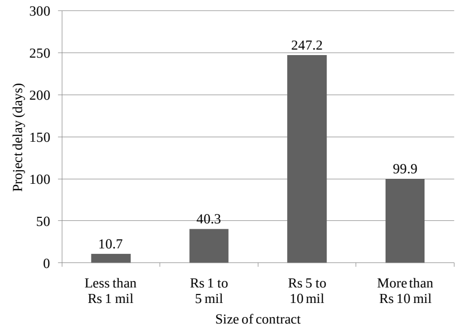


Figure 27. Project delays and size of contracts



Weather may be another potential determinant of post-award adjustments on the technical side. This is clearly an exogenous factor. In Nepal, heavy rain is one of the major constraints to project completion without delay. Thus, the amount of cumulative precipitation during the project implementation period, *rainduring*, is included in our models. On a simple correlation basis, our data appear to suggest that increased precipitation would cause cost overruns and project delays in the country (Figures 28 and 29).

One may think that unexpected increases or decreases in precipitation are more relevant to post-award contract adjustments than actual levels of precipitation. The reason is that potential contractors may already have anticipated normal precipitation and reflected it to their bids. If this is the case, actual precipitation may not impact on cost overruns or project delays. To test this possibility, another variable *unexpectedrain* is constructed by subtracting the average monthly precipitation in the one-year period prior to each tender from the actual precipitation per month during the project implementation period.

Figure 28. Cost overruns and precipitation during project implementation

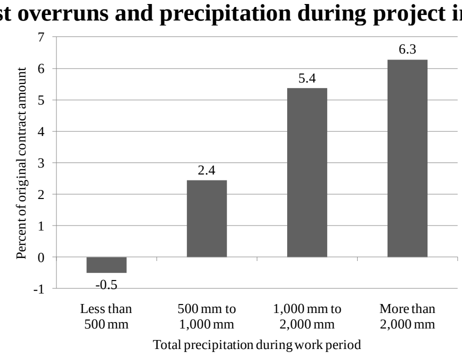
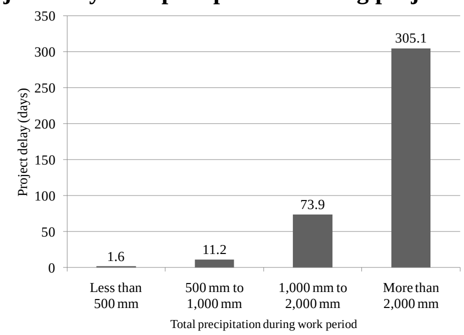


Figure 29. Project delays and precipitation during project implementation



As discussed, security is a major concern for contractors in Nepal. Strikes and intimidations would likely cause significant delays of rural road projects in Nepal. Thus, Equation (5) includes the number of security-related incidents during the project implementation period, denoted by *securityduring*. Note that this is not the same as the security variable that is used above. *securityduring* is defined by the number of incidents that actually happened during the project period. For the same reason as *unexpectedrain*, we also construct the number of unexpected security incidents during the project implementation period, compared to the monthly average during the one-year period prior to the bid submission (*unexpectedsecurity*).

In our sample, one-third of the contracts experienced some delays due to security concern or strikes. If more than 40 security incidents occurred in a project district during the project implementation period, the project is likely to experience about 7 percent of cost overruns, which are relatively large in our sample (Figure 30). In addition, the projects are likely to delay as well (Figure 31).

Figure 30. Cost overruns and security incidents during project implementation

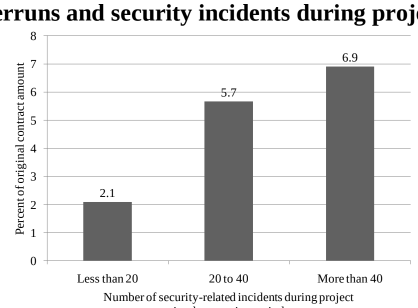
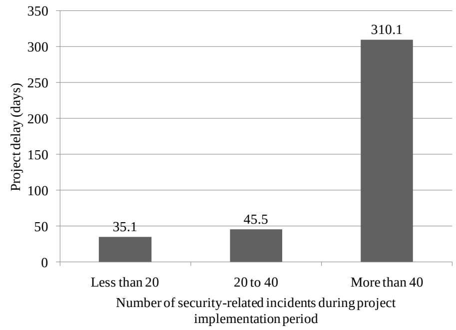


Figure 31. Project delays and security incidents during project implementation



Ex post contract adjustments may also be influenced by other institutional factors. One issue is that post-award contract adjustments may result from excess competition at the market. This is considered as a "winner's curse" phenomenon (e.g., Kagel and Levin, 1986; Klemperer, 1998; Hong and Shum, 2002; Athias and Nunez, 2006). If competition at the auction is intense, bidders are forced to be more aggressive. It may turn out that the winner was too optimistic. This will be captured by *num*. Our data indicate a certain possibility of this winner's curse. At the low level of competition, bidders seem to be induced to be more aggressive under competitive pressure, which results in cost overruns (Figure 32). Intense competition may also result in project delays. This is observed partly at the relatively high level of competition involving more than 6 contenders (Figure 33).

Figure 32. Cost overruns and number of bidders

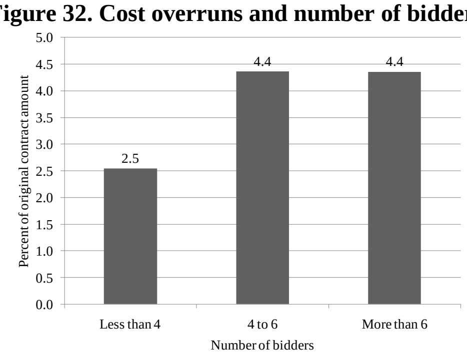
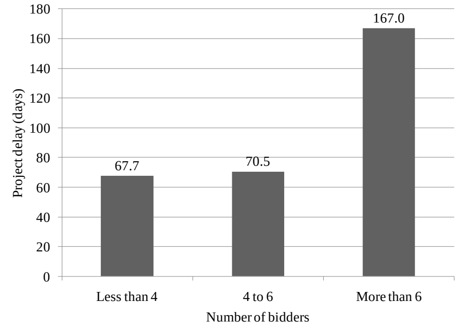


Figure 33. Project delays and number of bidders



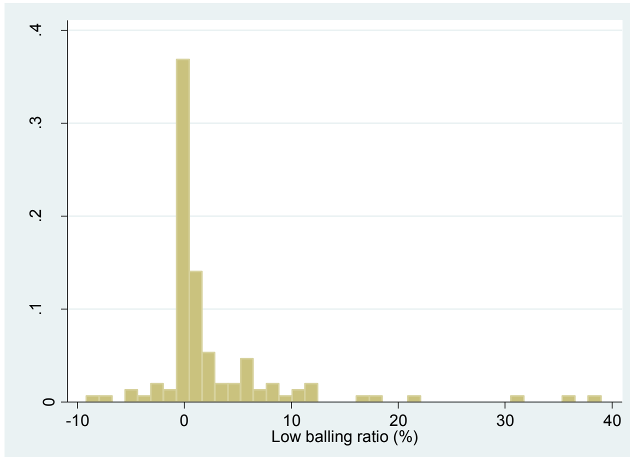
A relevant view to the above is that post-award amendments would be caused by the bidders' opportunistic behavior, such as low-balling (underbidding) strategy. This is a governance-related problem. The current procurement systems often fail to prevent bidders from taking the low-balling strategy. Bidders may already anticipate that infrastructure contracts would be likely amended after the contract award. If so, bidders would have strong incentives to manipulate their bids, win the contract and then initiate renegotiation. This is often observed in competitive bidding for complex objects, such as infrastructure projects (Guasch, 2004; Ware and others, 2007).

To test this hypothesis, the difference between the winning evaluated bid and the second lowest bid is calculated (*lowbid*).[13] In our data, there are a certain number of winning bids that substantially undercut the second lowest bidders. In most cases, the low balling ratio—relative to the second lowest bid amount—is less than 10 percent. But in some cases the difference exceeds 30 percent (Figure 34). That is, the winning bid is more than 30 percent lower than the second lowest bid.[14] There are another set of abnormal cases where the winning bids were not the lowest evaluated bids, possibly due to some technical

[13] An alternative variable that allows to test the low-balling hypothesis is the difference between the winning bid and the mean bid at that auction. This may have the advantage to see the case where the two lowest bidders would take the low-balling strategy. If this is the case, we cannot test the low-balling hypothesis by our low-balling indicator, *lowbid.* We constructed and tested both variables. The meaning regression results have been generated only when the low-balling is measured by our *lowbid*.
[14] Our *lowbid* is constructed by comparing the winning bids with the second lowest bids that were deemed to be substantially responsive in technical terms. Technically nonresponsive bids are ignored.

reasons.[15] In these cases, the difference between the winning bid and the second lowest bid can be negative.

Figure 34. Difference between winning bid and second lowest bid (%)



Ex post adjustments can also be related to the effectiveness of procurers to evaluate bids and bidders. One common view is that procurers would be bothered with a number of addenda, if the bid qualification process is compromised at the bid evaluation stage. If this is the case, the shorter bid evaluation period would likely result in a larger number of contract amendments. This is tested by our inefficiency measurement, *dayscontracting*, in Equation (5). Note that contracting with incompetent and faithless contractors is costly in particular in infrastructure projects. For example, in Madagascar, three road contracts were re-bided because of the unacceptably low quality of the contractor's performance. However, the contract cost turned out 37 percent higher than the original contract, when the contractor was reselected. This is because the costs of inputs, such as fuel and cement, increased during the procurement delay (Alexeeva, Padam, and Queiroz, 2008).

Quality of projects

Finally, the quality of project delivered is investigated:

[15] Based on the collected data, no detailed reasons are known.

$$Q_t = f(age_t, traffic_t, securityafter_t, rainafter_t, X_t) \tag{6}$$

To measure the quality of roads, *Q*, we use two measurements. One is a subjective indicator, which is a rating to by transport specialists who drove on the road, i.e., $rate_t$={1, 2, 3, 4}.[16] In this case, the ordered probit model is used to estimate Equation (6), because *rate* is an ordered discrete variable. Another measurement for *Q* is a more objective indicator, i.e., the average speed at which a normal vehicle actually ran on the rehabilitated or upgraded road (ln*speed*). In this case, the equation can be estimated by the ordinary (log)linear regression.

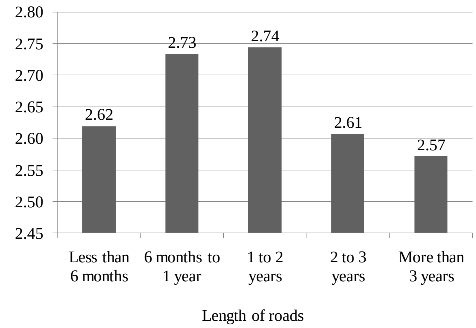
The quality of roads must of necessity depend on technical factors, such as the volume of traffic and how long the road has been used. In general, roads are deteriorating over time (Figure 35). *age* is the number of days for which the road has been used since the project was completed. In addition, heavy traffic would cause more road deterioration. The cumulative traffic volume, *traffic*, can be calculated by age multiplied by the average daily traffic (ADT), which was measured for each road segment by field visit.

The road condition may depend on weather, especially, precipitation. More precipitation would cause deterioration on the road surface. The cumulative amount of precipitation after the project completion, *rainafter*, is included in the model.

The quality of roads also depends on whether they are maintained periodically. As discussed above, roads are deteriorating anyway. The periodical maintenance is essential to keep the road quality high. To this end, security issues may be a potential problem. If security concern is severe, roads would not be able to be maintained properly. Therefore, the cumulative number of security-related incidents that occurred in each project district is also included in the model, denoted by *securityafter*.

[16] The rating has four grades: (i) very uncomfortable with continuous shakes and frequent slowdown and stops, (ii) uncomfortable with frequent shakes, (iii) fairly comfortable though occasionally jolting, and (iv) very comfortable throughout the entire road segment.

Figure 35. Average road quality rating by road age



Note: Rate 4 is the best quality and 1 is the lowest.

IV. Main Estimation Results and Policy Implications

Equilibrium bid function

The equilibrium bid function is first estimated by an ordinary least squares (OLS) technique. As theory predicts, the coefficient of the number of bidders is negative (Table 5). However, this may potentially be biased, because the endogeneity of the bidder participation is not controlled.

With the endogeneity taken into account, the competition effect has been found to be significant. The two-stage least squares (2SLS) regression, in which the number of bidders is replaced with the predicted value from a zero-truncated negative binomial model, provides a consistent estimate of the bid function. The bid elasticity with respect to competition is estimated at -0.285. Thus, if competition is intensified by 10 percent, bids are estimated to decline by 2.8 percent. The instrumental variable (IV) regression where the number of bidders is directly instrumented by *Z* (and other exogenous variables) shows the same result. The more competition, the lower procurement costs. In this model, the elasticity is slightly higher (in absolute terms) at -0.338.

The estimation results also show that security concern is a cost factor in Nepal. The coefficient of *securitybefore* is positive and significant across all the models. Thus, when security concern is high around a project area, firms would increase their bid prices. This implies that potential contractors would likely anticipate increases in project costs in insecure areas, either due to expected project delays or because they have to take security measures to prevent incidents. The elasticity of bid prices with respect to security incidence is about 0.23.

Engineering cost estimates turned out to be a good proxy of the actual bid amounts, after other specification differences are controlled.[17] The estimated coefficient is close to one in all the models. This is a good indication for the procurement planning capacity of district-level road agencies, DDCs. Contrary to our prior expectation, the firm location does not seem to be an important factor to determine bid prices. One empirical possibility is that the potential distance effect may have been captured by a combination of bidder location and project site dummy variables. In fact, if all the dummy variables for bidder and project locations are excluded, the significance of ln*dist* increases. But the p-value is 0.15, above the conventional threshold; thus, the impact of distance is still weak. Ethnicity does not affect bid prices, either.

[17] The principal component analysis identified the engineering cost estimate as the most influential variable among our independent variables representing technical specifications of projects. The vast majority of the differences in technical specifications can be explained by the engineering cost estimate, followed by some input variables, such as gravel and gabion.

Table 5. Estimated bid function

	OLS			2SLS with ztnb			IV		
	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
ln *num*	-0.134	(0.050)	***	-0.285	(0.123)	**	-0.338	(0.179)	*
ln *securitybefore*	0.234	(0.046)	***	0.237	(0.045)	***	0.234	(0.042)	***
ln *dist*	0.045	(0.040)		0.054	(0.039)		0.037	(0.040)	
D(*ethnicity*)	0.222	(0.156)		0.258	(0.161)		0.219	(0.165)	
ln *cost*	0.959	(0.038)	***	1.015	(0.059)	***	0.999	(0.049)	***
ln *length*	0.061	(0.048)		0.067	(0.048)		0.057	(0.050)	
ln *lane*	0.092	(0.225)		0.145	(0.236)		0.102	(0.217)	
ln *thickness*	0.030	(0.028)		0.048	(0.030)		0.037	(0.028)	
ln *gravel*	0.017	(0.012)		0.013	(0.013)		0.019	(0.012)	
ln *bitumen*	-0.028	(0.010)	***	-0.037	(0.012)	***	-0.029	(0.010)	***
ln *earth*	-0.008	(0.013)		0.014	(0.016)		0.015	(0.022)	
ln *brick*	0.014	(0.017)		0.016	(0.017)		0.012	(0.016)	
ln *gabion*	0.006	(0.011)		0.013	(0.012)		0.012	(0.012)	
ln *exavate*	0.003	(0.014)		0.007	(0.015)		0.006	(0.015)	
ln *cement*	0.002	(0.017)		-0.018	(0.023)		-0.014	(0.022)	
D(*postqualify*)	0.162	(0.153)		0.022	(0.176)		0.006	(0.220)	
Constant	-0.910	(0.482)	*	-1.658	(0.692)	**	-1.301	(0.591)	**
Obs.	599			591			591		
R-squared	0.893			0.891			0.889		
F-statistics	875.0			808.1					
Wald chi2							38941		
No. of dummy variables:									
Project districts	18			18			18		
Bidders' home districts	25			25			25		

Note: The dependent variable is the number of bidders, num. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively. 2SLS with ztnb = two stage least squares with the zero truncated negative binomial regression as a first stage. For this model, *num* is replaced with the predicted number of bidders from the first stage.

Bidder participation

To explore the bidders' entry strategy, a generalized count regression is performed. In addition, a probit model is also estimated with the observations of not only bidding firms but also firms that showed interest but did not enter the market. The results indicate that higher costs of bidding documents deter potential entrants from entering the market (Table 6). In the negative binomial model, the coefficient is negative and significant. The implied elasticity associated with the document price is estimated at -0.51 (Table 7). Therefore, a 10 percent reduction in costs of bidding documents could increase the number of bidders by 5 percent or invite 0.3 bidders more to public tenders.

The longer bid preparation period helps to enhance competition. The coefficient of *bidpreptime* is significant and positive in the negative binomial model. The implied elasticity is 0.64. Thus, if the bid preparation period is extended by 10 percent, 6 percent more bidders would apply.

According to the first stage regression of the instrumental variable (IV) estimator (presented above), more bidders would participate in the competition, if more firms are attracted at the initial stage of the public procurement. The coefficient of *bdnum* turned out to be significantly positive. This confirms a basic principle of the public procurement systems: The competition should open and nondiscriminatory with free entry. It is important to invite as many firms as possible to public tenders at the beginning.

Larger contracts are more attractive to potential bidders. It is not straightforward to assess the scale effect in our model, because the size of contracts is measured by more than one variable. But when focusing on the marginal effect of engineering cost estimates, the coefficient is 0.36. A 10 percent increase in cost estimates, holding everything else constant, would result in a 3-4 percent increase in bidder participation. It means that too small contracts are not profitable enough to motivate potential contractors to participate in public tendering. Recall that that the average contract amount is relatively small at about NRs 7.7 million or $110,000 in Nepal and that bidders have to bear some (implicit) entry costs regardless of whether they win or lose the contract.

Distance does matter to the bidder participation. According to our bid estimation results (Table 5), the firm location does not really matter to bid prices. But it does affect the bidders' entry strategy. The first stage of the IV regression indicates that firms located far from a project location are less likely to decide to enter the market. The estimated elasticity is small at -0.06 but statistically significant. If the distance between a project site and potential contractors increases by 50 km—approximately, a distance between two districts in Nepal, the expected number of bidders would decrease by about 2.5 percent. The probit model shows the similar results. The coefficient of ln*dist* is negative at -0.19, which is statistically significant. Therefore, it can be concluded that the firm location does not matter directly to bid prices but affect the bidders' participation decisions, which could in turn increase road procurement costs.

Security issues discourage bidder participation. In Nepal, there has been concern about intimidation and threats by incumbent firms as well as strikes and abductions in local areas. Our estimation results are supportive of this. The probit model has a negative and significant coefficient on the security variable. Thus, if more security-related incidents are expected in a project district, a fewer firms would apply.

Contrary to our expectation, ethnicity does not seem to affect the bidders' entry decision. This may be attributable to possible noise in our data. Our ethnicity variable, D(*ethnicity*), is constructed based on the only district-level information. It is set to one if the dominant ethnicity is the same between a project host district and a bidder's home district. It does not necessarily explain which ethnic group each bidding entity belongs to.

Table 6. Estimation of bidder participation decision

	Zero truncated negative binomial		1st stage of IV		Probit	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
bdnum	-0.002	(0.004)	0.104	(0.058) *		
bdcost	-0.0003	(0.0001) ***	0.178	(0.121)	0.0002	(0.0001)
bidpreptime	0.025	(0.010) ***	0.321	(0.092) ***	-0.009	(0.009)
securitybefore	0.005	(0.008)	-0.022	(0.050)	-0.024	(0.007) ***
ln *dist*			-0.060	(0.027) **	-0.190	(0.050) ***
D(*ethnicity*)			-0.089	(0.136)	-0.222	(0.207)
ln *cost*	0.362	(0.112) ***	0.018	(0.078)	-0.102	(0.116)
ln *length*	0.052	(0.099)	0.029	(0.070)	0.161	(0.075) **
ln *lane*	-0.051	(0.370)	0.001	(0.158)	0.028	(0.412)
ln *thickness*	0.072	(0.060)	-0.014	(0.043)	0.100	(0.058) *
ln *gravel*	-0.010	(0.027)	-0.001	(0.012)	-0.081	(0.034) **
ln *bitumen*	-0.010	(0.026)	0.014	(0.015)	-0.055	(0.024) **
ln *earth*	0.124	(0.038) ***	0.105	(0.016) ***	0.054	(0.032) *
ln *brick*	-0.022	(0.028)	-0.045	(0.014) ***	-0.021	(0.037)
ln *gabion*	0.054	(0.024) **	0.031	(0.013) **	0.038	(0.024)
ln *excavate*	0.006	(0.023)	0.002	(0.010)	-0.007	(0.016)
ln *cement*	-0.126	(0.032) ***	-0.079	(0.011) ***	-0.071	(0.028) **
D(*postqualify*)	-0.752	(0.218) ***	-0.716	(0.161) ***	0.653	(0.245) ***
Constant	-4.501	(1.330) ***	-1.468	(0.763) *	0.570	(1.661)
Obs.	118		591		2119	
Wald chi2	1498.88				436.39	
R-squared			0.779			
F-statistics			305.25			
Pseudo R2					0.180	
No. of dummy variables:						
Project districts	18		18		17	
Bidders' home districts	0		25		28	

Note: The dependent variable is the number of bidders, *num*, for the zero truncated negative binomial regression. For the 1st stage of the instrumental variable regression, the first four independent variables are in logarithm. In the probit model, the dependent variable is a binary variable which is set to 1 if a potential contractor participates in competitive bidding, and zero otherwise. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively.

Table 7. Implied marginal effect on the number of bidders

	Marginal effect	Std. Err.	
bdnum	-0.051	(0.088)	
bdcost	-0.506	(0.184)	***
bidpreptime	0.640	(0.250)	***
securitybefore	0.053	(0.086)	
cost	0.362	(0.112)	***

Efficiency in contracting

One potential disadvantage of increasing the size of the contract to intensify competition is that the administrative costs of evaluating bids and bidders are likely to go up. Our evidence is supportive of this. In the contract efficiency regressions, the coefficient of engineering cost estimates has been found positive and significant in all the models (Table 8). There are two reasons for this. First, it takes longer to evaluate bids and bidders in large contracts; large-scale works tend to be financially valuable and technically complex. As a result, the size of contracts is an important determinant of the procurement efficiency.

Second, larger contracts attract more contenders, as shown above. Firms are more interested in public tenders for large packages. Consequently, increased competition adds to the evaluation costs of procurers. This effect may be captured partly by the coefficient on ln*cost*, because of the correlation between the two variables. The coefficient of the number of bidders is insignificant in the first three specifications of Table 8. But when all the variables representing the scale of contracts are excluded from the model, the effect of increased competition becomes clearer; the more bidders, the less efficient contracting process. This is simply because it takes more time to evaluate more bids and bidders.

No evidence is found that security issues would retard the bid evaluation process. In all the regressions on *dayscontracting*, the coefficient of *securitybefore* is found insignificant. There may be a data issue here. Recall that our security variable is constructed to represent the general level of security concern at the district level. It may or may not be linked explicitly to security incidents related to the public road procurement. However, as far as our data are concerned, the bid evaluation and contract award process per se does not seem to be affected directly by possible intimidations or any other complaints from bidders. Rather, security is a matter of more vital concern to the bidder participation, as discussed above (Table 6).

(In)Efficiency in contract awarding crucially depends on district-specific unobservables, such as government effectiveness and procurers’ capacity. In the models, there are significant fixed effects across districts. Formally, the Wald test statistic for the first column model is estimated at 3.28, which is greater than the *F* statistic with 18 numerator and 86 denominator degrees of freedom. Using the district of Banke as a baseline, Dhading and Nuwakot are clearly efficient than other districts. By contrast, Kapilvastu and Palpa look less efficient for some reasons.

Table 8. OLS estimation of efficiency in contract awarding

	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
ln *num*	-0.110	(0.145)		-0.060	(0.118)					0.591	(0.116)	***	0.575	(0.140)	***
ln *securitybefore*	0.065	(0.112)					0.071	(0.113)					-0.044	(0.126)	
ln *cost*	0.534	(0.164)	***	0.549	(0.114)	***	0.509	(0.162)	***						
ln *length*	-0.123	(0.132)		-0.249	(0.107)	**	-0.125	(0.130)							
ln *lane*	-0.131	(0.375)		-0.098	(0.393)		-0.133	(0.368)							
ln *thickness*	-0.065	(0.122)		-0.129	(0.090)		-0.067	(0.125)							
ln *gravel*	0.065	(0.059)		0.015	(0.045)		0.065	(0.059)							
ln *bitumen*	0.020	(0.052)		0.012	(0.044)		0.022	(0.054)							
ln *earth*	-0.052	(0.058)		0.007	(0.046)		-0.060	(0.059)							
ln *brick*	0.002	(0.054)		0.073	(0.061)		0.003	(0.054)							
ln *gabion*	0.053	(0.039)		-0.003	(0.029)		0.048	(0.037)							
ln *excavate*	0.022	(0.025)		0.031	(0.019)		0.019	(0.024)							
ln *cement*	-0.138	(0.042)	***	-0.114	(0.031)	***	-0.129	(0.038)	***						
D(*postqualify*)	-0.145	(0.411)		0.369	(0.324)		-0.065	(0.409)		1.510	(0.295)	***	1.149	(0.311)	***
Constant	-4.064	(2.084)	**	-4.626	(1.427)	***	-3.871	(2.076)	*	1.026	(0.402)	**	1.453	(0.662)	**
Obs.	119			154			119			155			120		
R-squared	0.710			0.719			0.708			0.463			0.496		
F-statistics	19.80			24.44			20.34			13.40			23.20		
No. of dummy variables:															
Project districts	18			18			18			18			18		

Note: The dependent variable is the number of days required to award a contract after the bid openning, *dayscontracting*. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively.

Contract management

Security has been found the most important factor that caused ex post contract amendments—both cost overruns and project delays. In the regressions on cost overruns, the coefficient of ln *securityduring* is found significantly positive at 1.24 (Table 9). But *unexpectedsecurity* does not have a significant coefficient. Thus, road projects would experience large cost overruns, if more security-related incidents happened during the implementation period, even though they were anticipated prior to public tendering. The implied elasticity is about 0.33.

In addition, security incidents have a positive and significant impact on ln *Delay* (Table 10). Not surprisingly, security incidents would cause project delays. While security incidents occur, a project will be interrupted. The elasticity is estimated at about 1.1. If a contractor is faced with 10 percent more incidents, the project would be delayed by the same percentage or for 2-3 weeks.[18]

Heavy rainfall causes project delays as well. But it may not increase cost overruns. This is consistent with our expectation. In rural road projects, which are technically simple, it is less likely that contractors would encounter unexpected geotechnical issues. Rather, heavy rain would likely delay civil works. In the regression on delays, *rainduring* has a positive and significant coefficient of 0.32. *unexpectedrain* also has a significant coefficient. Thus, the project delay would increase with precipitation during the project implementation. This is a reasonable finding, because road work cannot be carried out when it rains. If it rains 10 percent more than usual, the project would delay additionally by 3 percent or 3 days, on top of an average project delay of 107 days.

Intense competition in public tendering results in mitigating the risk of post contract amendments. The number of bidders has a negative coefficient in all the specifications. The

[18] In the sample, the original project duration is about 185 days on average, and the actual project duration is about 290 days. The average project delay is about 107 days.

coefficient is particularly significant in the regressions on cost overruns. It is interpreted as one of the positive benefits from competitive pressure in the market. Contractors that were selected through intense competitive bidding are more likely to be well disciplined and therefore less likely to provoke renegotiation about costs or miss the project completion date. The work is more likely to be delivered on schedule, except in the case that exogenous factors, such as security events and weather, occur.

Notably, this finding contradicts the winner's curse hypothesis that excessive competition would result in more ex post contract amendments. Our finding suggests that intense competition is conducive to avoiding post contract adjustment. This is more consistent with the independent private value paradigm of auction theory, in which competition plays an important role in lowering the equilibrium bid. In addition, contracts are unlikely to be amended, because bidders know their own values attached to an object.[19]

The low-balling strategy will end up with a retard of projects. The coefficient of *lowball* is found significant and positive in the regressions on project delays. Recall that lowball is defined by the difference between the winning bids and the second lowest bids. Thus, a positive coefficient means that more delays will happen if the winning bid undercuts the second price significantly. On the other hand, there is no evidence that the low-balling strategy would cause cost overruns. The coefficient is positive but not significant.

The coefficient of *dayscontracting*, a proxy of inefficiency in contracting, is found positive and significant in both cost overrun and project delay equations. This is inconsistent with the view that procurers would be bothered with post contract adjustments if the qualities of bids and bidders are not carefully assessed before the contract award. Worse, many post adjustments will happen even if procurers spend more time for the bid evaluation.

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[19] By contrast, under the common value paradigm, bidders do not ex ante know the true value of an object. As a result, bidders may over- or under-estimate the value, initiating ex post contract amendments (e.g., Kagel and Levin, 1986; Klemperer, 1998; Hong and Shum, 2002; Athias and Nunez, 2006). With such a case anticipated, the equilibrium bid may first decrease with the number of bidders, reflecting increased competition, but with more competition, bidders will recognize the risk of underestimating the true project costs and raise their bids (Paarsch, 1992).

Underlying reasons remain open to discussion. One possibility is that poor governance would likely loosen contractors' incentives and at the same time increase the risk of corruption and collusion in the procurement process. As discussed, the lengthy contract process is a yellow flag signaling weak governance in public procurement systems. At the same time, poor governance would allow contractors to exploit the opportunities of strategic cost overruns and project delays.

Overall, security stands out as the most important factor to explain ex post contract adjustments. Security issues cause both cost overruns and project delays. Competitive pressure will help to prevent post contract amendments, especially cost overruns. The low-balling strategy will increase the risk of project delays.

Regarding non-institutional variables, the estimation results consistently show that two inputs would bring about cost overruns: bitumen and earthworks. Bitumen is a relatively expensive input in rural road projects of Nepal, and its costs may be sensitive to external factors, such as energy prices. As a result, bitumen would emerge as an important cost overrun factor. In our sample, about half of the works used some bitumen. Earthworks are preparatory works, including land grading and leveling, for roads. They are one of the main work activities in our rural road projects. Depending on project site conditions, unanticipated additional earthworks may be required. In the sample, almost all contracts include some earthworks, except for 6 contracts. The implication is that the quality of the bidding documents is important. If a project is predefined correctly with proper specifications, these cost overruns will be less likely to occur.

Larger contracts would bring about larger post-award adjustments, particularly project delays. This may be simply because larger projects are technically complex. The coefficient of ln*cost* in the last column model of Table 10 is significantly positive at 0.71. Hence, larger contracts would undergo more delays. A 10 percent larger contract would result in increasing project delays by 7 percent, assuming that everything else is constant,

Table 9. OLS estimation of cost overruns

	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
ln *securityduring*	1.245	(0.645) **													2.022	(0.698) ***
ln *unexpectedsecurity*			-0.157	0.5009												
ln *rainduring*					-0.316	(0.265)									-1.094	(0.336) ***
ln *unexpectedrain*							-0.193	(0.204)								
ln *num*									-2.046	(0.710) ***					-3.701	(0.975) ***
ln *lowbid*											0.050	(0.097)			0.024	(0.092)
ln *dayscontracting*													1.460	(0.600) **	0.617	(0.755)
ln *cost*	-0.032	(0.821)	0.1131	0.866	0.945	(0.755)	0.842	(0.735)	0.990	(0.658)	0.834	(0.758)	0.029	(0.755)	0.846	(0.869)
ln *length*	-1.821	(0.727) **	-1.563	0.7743 **	-1.899	(0.687) ***	-1.749	(0.691) **	-1.671	(0.649) ***	-1.629	(0.863) *	-1.395	(0.702) **	-1.727	(0.750) **
ln *lane*	1.072	(3.606)	0.0911	4.6242	2.028	(3.540)	2.409	(3.575)	1.485	(3.448)	1.705	(3.632)	2.410	(3.477)	0.262	(3.918)
ln *thickness*	-0.241	(0.493)	0.3371	0.6176	-0.372	(0.508)	-0.227	(0.509)	-0.229	(0.482)	-0.738	(0.522)	-0.170	(0.513)	-0.128	(0.496)
ln *gravel*	-0.163	(0.220)	0.1492	0.2943	-0.038	(0.203)	-0.085	(0.221)	-0.053	(0.217)	-0.151	(0.219)	-0.089	(0.218)	-0.231	(0.210)
ln *bitumen*	0.941	(0.242) ***	0.9046	0.2979 ***	0.966	(0.271) ***	0.924	(0.263) ***	0.903	(0.249) ***	1.008	(0.265) ***	0.928	(0.269) ***	0.909	(0.246) ***
ln *earth*	0.676	(0.299) **	0.4198	0.3362	0.505	(0.250) **	0.515	(0.253) **	0.691	(0.260) ***	0.621	(0.260) **	0.527	(0.248) **	0.855	(0.325) ***
ln *brick*	-0.242	(0.396)	0.0338	0.5058	0.103	(0.399)	0.119	(0.401)	0.008	(0.377)	-0.013	(0.431)	-0.002	(0.391)	-0.343	(0.416)
ln *gabion*	-0.071	(0.232)	0.2795	0.3225	-0.097	(0.231)	-0.127	(0.226)	0.004	(0.229)	-0.163	(0.238)	-0.108	(0.222)	0.014	(0.234)
ln *exavate*	-0.199	(0.131)	-0.041	0.1624	-0.168	(0.135)	-0.186	(0.138)	-0.127	(0.128)	-0.141	(0.151)	-0.227	(0.141) *	-0.191	(0.137)
ln *cement*	0.224	(0.234)	0.0198	0.3035	0.049	(0.240)	0.038	(0.239)	0.013	(0.224)	0.052	(0.244)	0.226	(0.252)	0.059	(0.250)
D(*postqualify*)	3.954	(2.329) *	0.2357	1.9315	4.056	(2.070) **	3.693	(2.137) *	3.084	(2.075)	3.911	(2.209) *	3.037	(2.033)	4.545	(2.577) *
Constant	-6.759	(9.272)	-1.570	(9.934)	-13.976	(8.553) *	-14.052	(8.866)	-14.925	(7.980) *	-15.158	(9.170) *	-7.742	(8.766)	-12.152	(9.071)
Obs.	152		95		155		154		155		142		154		138	
R-squared	0.558		0.638		0.540		0.542		0.559		0.544		0.556		0.624	
F-statistics	9.68		38.17		9.29		8.77		9.61		8.54		8.14		10.58	
No. of dummy variables:																
Project districts	18		18		18		18		18		18		18		18	

Note: The dependent variable is the cost overrun rate, *overrun*. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively.

Table 10. OLS estimation of project delays

	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
ln *securityduring*	1.131	(0.273) ***													1.133	(0.243) ***
ln *unexpectedsecurity*			0.047	(0.191)												
ln *rainduring*					0.326	(0.150) **									0.043	(0.162)
ln *unexpectedrain*							0.170	(0.090) *								
ln *num*									-0.509	(0.346)					-0.504	(0.355)
ln *lowbid*											0.089	(0.039) **			0.105	(0.035) ***
ln *dayscontracting*													0.820	(0.252) ***	0.497	(0.369)
ln *cost*	1.000	(0.299) ***	1.424	(0.452) ***	1.449	(0.297) ***	1.707	(0.275) ***	1.776	(0.280) ***	1.519	(0.305) ***	1.286	(0.317) ***	0.706	(0.325) **
ln *length*	-0.962	(0.283) ***	-0.002	(0.340)	-0.851	(0.312) ***	-0.980	(0.344) ***	-0.943	(0.340) ***	-1.423	(0.295) ***	-0.759	(0.314) **	-1.072	(0.283) ***
ln *lane*	0.902	(2.356)	0.725	(2.036)	1.500	(2.157)	1.422	(2.215)	1.339	(2.044)	1.844	(2.053)	1.599	(2.042)	1.388	(2.416)
ln *thickness*	-0.326	(0.182) *	0.173	(0.350)	-0.393	(0.202) *	-0.521	(0.223) **	-0.365	(0.201) *	-0.329	(0.242)	-0.290	(0.188)	-0.138	(0.193)
ln *gravel*	-0.024	(0.116)	0.067	(0.127)	0.022	(0.116)	0.048	(0.113)	0.035	(0.114)	0.063	(0.121)	0.020	(0.125)	-0.072	(0.116)
ln *bitumen*	-0.113	(0.081)	-0.526	(0.160) ***	-0.123	(0.094)	-0.094	(0.095)	-0.126	(0.098)	-0.067	(0.102)	-0.125	(0.087)	-0.086	(0.086)
ln *earth*	-0.195	(0.118) *	-0.392	(0.135) ***	-0.262	(0.105) **	-0.298	(0.104) ***	-0.274	(0.100) ***	-0.253	(0.105) **	-0.316	(0.101) ***	-0.107	(0.128)
ln *brick*	-0.122	(0.127)	-0.029	(0.157)	0.042	(0.125)	0.080	(0.125)	0.068	(0.124)	0.171	(0.115)	0.030	(0.115)	-0.064	(0.115)
ln *gabion*	-0.112	(0.084)	0.012	(0.119)	-0.135	(0.090)	-0.121	(0.093)	-0.101	(0.099)	-0.126	(0.095)	-0.125	(0.089)	-0.083	(0.084)
ln *excavate*	0.051	(0.058)	0.070	(0.094)	0.061	(0.058)	0.070	(0.055)	0.081	(0.055)	0.061	(0.061)	0.043	(0.059)	0.022	(0.059)
ln *cement*	-0.207	(0.090) **	-0.183	(0.165)	-0.280	(0.096) ***	-0.297	(0.097) ***	-0.332	(0.093) ***	-0.279	(0.096) ***	-0.226	(0.099) **	-0.136	(0.090)
D(*postqualify*)	0.720	(0.866)	2.142	(0.956) **	0.474	(0.846)	0.707	(0.811)	0.649	(0.782)	0.936	(0.917)	0.464	(0.773)	0.761	(0.973)
Constant	-12.081	(3.499) ***	-17.331	(5.110) ***	-17.007	(3.405) ***	-18.727	(3.370) ***	-18.616	(3.396) ***	-16.374	(3.602) ***	-14.692	(3.730) ***	-10.597	(3.559) ***
Obs.	152		95		155		154		155		142		154		138	
R-squared	0.607		0.513		0.562		0.553		0.548		0.613		0.572		0.709	
F-statistics	18.40		94.16		12.91		13.46		12.16		12.77		12.85		23.39	
No. of dummy variables:																
Project districts	18		18		18		18		18		18		18		18	

Note: The dependent variable is the number of days of project delays in logarithm, ln *delay*. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively.

Quality of projects delivered

To examine the quality of roads the ordered probit regressions are performed. The results show that it depends on the duration of use of upgraded roads, traffic volume, precipitation and security issues (Table 11). In the ordered probit model with *age*, the road quality ratings are estimated to deteriorate over time; the coefficient is -0.57. This is interpreted as a depreciation rate of road assets affected by various factors. The results also show that traffic damages road surfaces; the quality ratings would decline, as the volume of traffic increases. Precipitation is also estimated to have a negative effect on the road quality. This is simply because precipitation also degrades road surfaces.

Security incidents have been found the most important factor. The number of security incidents that occurred after the project completion has a negative and significant coefficient of -0.42. In addition, when all these factors are taken into account simultaneously, the security impact stands as a dominant determinant. This may be interpreted slightly differently than the other variables discussed above. It implies that periodical road maintenance would be delayed or hampered where security concern is high. As a result, the road quality would deteriorate and be rated as poor. The finding is consistent with a view that periodical maintenance is essential to keep the quality of roads high in the existing literature. Especially, roads surfaces are considered vulnerable in Nepal, because of their unpaved surfaces as well as raininess of the country.

The quality of roads also depends on road specifications. Roads built to a high specification are more likely to be rated high. The coefficients of *lane* and *thickness* are consistently positive and significant across the models. Thus, not surprisingly, the road conditions would be good if the road surface is thicker. Wider roads also normally follow higher standards and thus tend to be in good condition.

When the quality is measured by the average speed of the traffic, the security issue is once again found an important constraint to maintain the road conditions (Table 12). In addition, the road quality deteriorates with precipitation, as expected. These effects are significant in the last column model.

One unexpected result is that the average speed increases with the traffic volume. Our prior expectation is that the quality of roads decreases with the traffic volume. It seems that there is an endogeneity problem in this result. A good quality road would allow to drive faster, which would also motivate more people to use the road. As a result, the traffic volume is positively correlated with the average driving speed.

Table 11. Ordered probit regression of road quality rating

	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
ln *age*	-0.567	(0.162) ***								
ln *traffic*			-0.328	(0.099) ***					0.200	(0.257)
ln *securityafter*					-0.429	(0.133) ***			-0.679	(0.391) *
ln *rainafter*							-0.557	(0.146) ***	-0.290	(0.291)
ln *cost*	0.035	(0.324)	0.077	(0.340)	0.073	(0.311)	0.053	(0.322)	0.028	(0.332)
ln *length*	-0.151	(0.259)	-0.128	(0.269)	-0.088	(0.260)	-0.154	(0.260)	-0.106	(0.274)
ln *lane*	3.329	(0.915) ***	4.086	(0.966) ***	3.017	(0.907) ***	3.631	(0.920) ***	3.904	(0.987) ***
ln *thickness*	0.390	(0.176) **	0.365	(0.176) **	0.387	(0.175) **	0.393	(0.180) **	0.287	(0.171) *
ln *gravel*	0.071	(0.074)	0.081	(0.083)	0.088	(0.079)	0.065	(0.075)	0.086	(0.087)
ln *bitumen*	-0.055	(0.075)	-0.057	(0.075)	-0.061	(0.075)	-0.054	(0.075)	-0.056	(0.074)
ln *earth*	0.006	(0.076)	0.050	(0.079)	-0.040	(0.080)	0.006	(0.075)	0.024	(0.084)
ln *brick*	0.063	(0.112)	0.088	(0.119)	0.026	(0.131)	0.073	(0.118)	0.069	(0.160)
ln *gabion*	0.141	(0.097)	0.082	(0.093)	0.141	(0.095)	0.131	(0.097)	0.121	(0.096)
ln *excavate*	-0.110	(0.049) **	-0.144	(0.048) ***	-0.115	(0.049) **	-0.122	(0.050) **	-0.144	(0.047) ***
ln *cement*	0.010	(0.090)	-0.004	(0.096)	0.015	(0.092)	0.013	(0.093)	-0.039	(0.108)
D(*postqualify*)	0.396	(0.657)	-0.005	(0.673)	0.152	(0.661)	0.338	(0.655)	-0.151	(0.682)
Obs.	136		128		133		136		125	
Wald chi2	181.11		185.06		188.48		196.97		201.52	
Pseudo R2	0.482		0.512		0.480		0.485		0.522	
No. of dummy variables:										
Project districts	18		18		18		18		18	

Note: The dependent variable is the quality rating. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively. Due to multicollinearity, ln *Age* is omitted from the last column model.

Table 12. OLS estimation of average traffic speed

	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
ln *Age*	0.007	(0.042)													
ln *Traffic*				0.044	(0.017)	**							0.207	(0.042)	***
ln *securityafter*							0.0002	(0.037)					-0.271	(0.070)	***
ln *rainafter*										-0.005	(0.032)		-0.044	(0.023)	*
ln *cost*	0.082	(0.057)		0.068	(0.058)		0.081	(0.057)		0.082	(0.057)		0.042	(0.055)	
ln *length*	0.120	(0.038)	***	0.160	(0.039)	***	0.114	(0.037)	***	0.115	(0.037)	***	0.181	(0.032)	***
ln *lane*	0.244	(0.267)		0.286	(0.248)		0.224	(0.270)		0.248	(0.269)		0.333	(0.164)	**
ln *thickness*	0.010	(0.032)		0.053	(0.029)	*	0.008	(0.032)		0.009	(0.031)		0.051	(0.029)	*
ln *gravel*	0.014	(0.015)		0.010	(0.014)		0.015	(0.016)		0.014	(0.015)		0.003	(0.016)	
ln *bitumen*	-0.031	(0.013)	**	-0.037	(0.013)	***	-0.030	(0.013)	**	-0.030	(0.013)	**	-0.032	(0.012)	***
ln *earth*	-0.019	(0.017)		-0.022	(0.017)		-0.019	(0.020)		-0.018	(0.017)		-0.018	(0.017)	
ln *brick*	-0.014	(0.018)		0.004	(0.018)		-0.019	(0.018)		-0.014	(0.017)		0.015	(0.016)	
ln *gabion*	0.001	(0.014)		-0.003	(0.014)		0.002	(0.013)		0.002	(0.013)		0.006	(0.013)	
ln *excavate*	-0.004	(0.010)		-0.008	(0.009)		-0.004	(0.010)		-0.004	(0.010)		-0.008	(0.009)	
ln *cement*	0.015	(0.014)		0.016	(0.014)		0.016	(0.014)		0.015	(0.014)		0.011	(0.014)	
D(*postqualify*)	-0.081	(0.104)		-0.028	(0.109)		-0.100	(0.107)		-0.085	(0.104)		0.004	(0.094)	
Constant	1.754	(0.738)	**	1.128	(0.747)		1.850	(0.699)	***	1.849	(0.734)	**	0.400	(0.812)	
Obs.	148			141			145			148			138		
R-squared	0.478			0.714			0.675			0.678			0.759		
F-statistics	12.86			13.48			13.33			12.97			19.41		
No. of dummy variables:															
Project districts	18			18			18			18			18		

Note: The dependent variable is the average speed in logarithm. Robust standard errors are shown in parentheses. *, **, *** indicate the statistical significance at the 10%, 5% and 1%, respectively. Due to multicollinearity, ln *Age* is omitted from the last column model.

V. Policy Discussion

There are a variety of findings in our estimation results. Important, our empirical analysis provides quantitative assessment to suggest possible policy options for improving the performance of public road procurement and contracting. Some important policy implications are as follows:

Competition needs to be enhanced particularly in government owned projects

Competition is the most important factor to bring down road procurement costs. The level of competition is clearly insufficient in some public tenders in Nepal. In particular in government owned projects, the average competition is about 4.5, unfavorably compared to an average of 7.3 in World Bank financed projects (Table 13). Greater efforts are required to invite more potential contractors in the government's projects. If the competition is increased to the same level as the World Bank projects, the procurement costs of government-financed roads are estimated to decline by about 20 percent.[20] If this is applied uniformly to our sample projects, which is composed of 155 road upgrading works, about NRs220 million or $3 million could be saved.

The optimal level of competition may be seven bidders or more in the Nepal case. How many bidders are required for an auction to be sufficiently competitive is a difficult question. It must depend on individual cases and policy objectives to be achieved. If we apply one analytical approach that defines competition as sufficient when the number of bids exceeds (Estache and Iimi, 2011), the optimal level that could generate a statistically significant impact on the equilibrium bid strategy is estimated at seven bidders or more in our case. The IV estimation with a partially nonlinear specification for the number of bidders, in which *num* is replaced with a set of the dummy variables for individual *num*,[21] shows that the

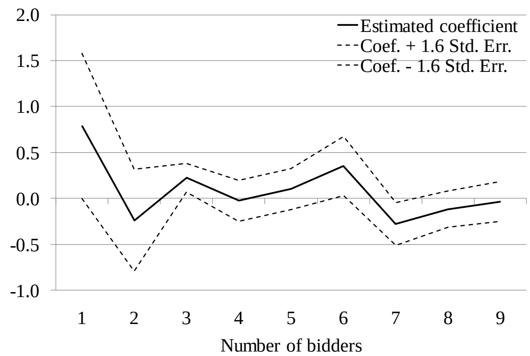
[20] This is calculated based on the IV result.
[21] This is considered as the most flexible functional form to specify the competition effect.

equilibrium bid broadly decreases with the number of bidders and that the statistical significance would taper off once the number of bidders reaches seven (Figure 36). About half of World Bank financed projects do not reach this level of competition. Nearly 80 percent of government financed projects are estimated to have insufficient competition (Figure 37). Too small contracts are often less attractive to firms, because of high transaction costs, which would be incurred regardless of the size of projects.

Table 13. Average number of bidders

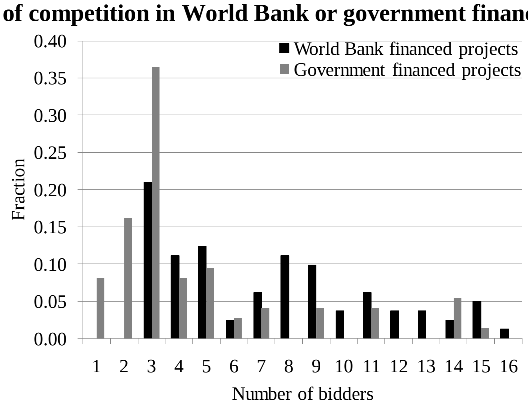
	Obs	Mean	Std. Dev.	Min	Max
World Bank project	82	7.28	3.78	3	16
Government project	74	4.51	3.50	1	15

Figure 36. Coefficients of numbers of bidders estimated by partially nonlinear IV regression



Note: The number of bidders equal to 10 or more is used as a baseline.

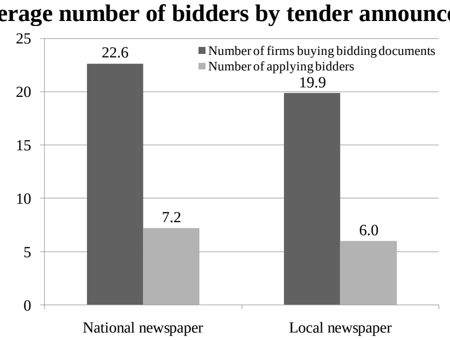
Figure 37. Levels of competition in World Bank or government financed road projects



Wider distribution of public tender information at cheaper costs will increase competition as well as improve transparency and accountability

Our findings indicate that attracting more interest at the initial stage of competition is important to enhance actual competition. To attract more interest and bidders, tender notices should be distributed widely. One measure is to advertize public tenders on national newspapers, rather than local ones. In our data, it is clear that more firms showed interest when tenders were advertized on national newspapers (Figure 38). If the media is changed from local to national newspapers, bidders are estimated to increase by about 20 percent, which would contribute to decreasing the procurement costs by 6-7 percent. [22]

Figure 38. Average number of bidders by tender announcement domain



E-bidding or e-procurement can contribute to distributing tender information even more widely and timely. The Nepal government has recently introduced the e-submission system in the road sector.[23] This is now being applied to other procuring agencies, such as the Department of Irrigation. The Government has decided to make e-procurement mandatory in public procurement estimated over NRs20 million in 2011 and intends to expand it to all procurement from the next year. These efforts are clearly consistent with our findings.

[22] This is calculated based on the IV result.
[23] In our sample data, the road contracts were advertized through traditional mass media, such as newspapers, e-bidding can reduce the entry cost of firms.

Based on our estimation results, three more bidders would enter the market if bidding documents were distributed free of charge, for instance, on the website.[24] The cost effectiveness of this measure is clear:[25] It could reduce the cost of road procurement works by 17 percent, because of the competition effect. The expected gains are estimated at NRs 187 million or $2.5 million (Table 14). On the other hand, the government would have to lose the current revenue from bidding document sales, which amount to about NRs 7.7 million or $0.1 million in total for 155 sample contracts. Thus, the expected gains from making bidding documents charge-free are far greater than the opportunity costs.

Table 14. Scenario analysis of making bidding documents free of charge

Revenue being lost:		
Average price of bidding documents (NRs)	1,548	
Number of bidding documents sold	3,672	
Total revenue from sales of bidding documents (NRs million)		7.77
Potential gains from intensified competition		
Elasticity of bidder participation with respect to bidding document costs	-0.51	
Elasticity of bid prices with respect to bidder participation	-0.34	
Expected reduction in bids by making bidding documents charge-free (%)	17.1	
Total cost savings (NRs million)		186.5

Longer bid preparation periods encourage bidder participation in public tenders

We found that the longer bid preparation period would enable more firms to participate in public tendering. As stipulated in the procurement guidelines, it is important to grant sufficient time for firms to prepare bids. By doing so, even inexperienced contractors are allowed to participate in auctions, thereby intensifying competition in the market. Of particular note, the extension of the bid preparation period is a no-cost measure for procurers. Governments may have to make some efforts toward preparing public tenders ahead of time. But this can be accommodated by other administrative efficiency gains, for instance, by

[24] This is estimated based on the zero-truncated negative binomial regression result.
[25] This illustration does exaggerate the expected impact of lowering the cost of bidding documents, because the estimated elasticities should be interpreted as a marginal effect. Distributing bidding documents free of charge is a large change, though it may not be economically large. However, the direction of the expected impact is clear: Lower bidding document prices will invite more bidders, reducing procurement costs.

introducing e-procurement, which can increase the efficiency in distributing the tender-related information and collecting the bid-related information. As the result, procurers can extend the bid preparation period without compromising anything.

In Nepal, some of the government owned projects have extremely short bid preparation periods. While an average of 31 days are allowed for the bid preparation in World Bank projects, 21 days are granted in the government owned projects (Table 15). As an indicative target, 30 days may have to be given for bid preparation. About 70 percent of World Bank contracts satisfy this target, but the majority of the government financed projects are below the threshold. By increasing the bid preparation period by 10 days in the government projects, 1.5 bidders would additionally enter the market according to our estimation result.[26] This would then reduce the equilibrium bid by about 8 percent, which would materialize a cost savings of NRs14.9 million or $0.2 million in the sample government projects in total.

Table 15. Average bid preparation period (days)

	Obs	Mean	Std. Dev.	Min	Max
World Bank project	82	31.1	6.6	15	52
Government project	73	21.6	9.0	6	33

Local contractors' capabilities need to be fostered to enhance competition

Our estimation results show that firm location does not matter to bid prices but influences the bidder entry strategy. If a project site is far from firms' locations, they are less likely to apply for the public tender. Hence, the local contractors' capacity will emerge as an important challenge for the country. Clearly, more local enterprises exist in some districts than others. Particularly, the share of local firms in the pool of potential contractors is low in the districts of Kailali, Palpa and Rautahat (Figure 39).[27] In addition, local firms do not appear

[26] Ditto.

[27] There is no significant difference even if the figure is calculated with the data of firms that actually participated in the competition, because there is no systematic difference in firms' entry decisions between local and nonlocal firms. The probability of participation is slightly higher for local firms (0.31) than nonlocal enterprises (0.26).

competitive enough, despite their potential advantages of proximity to the project location. Local bids are slightly higher than nonlocal bids (Table 16). In the bid regression, the dummy variables representing bidders' origin districts vary considerably. While companies from Siraha are systematically found competitive, firms from Rupandehi are found less competitive in the road procurement market. Firms originated from Kathmandu are found to be equally comparable with others. Thus, greater efforts may need to be made to develop the capacity of local businesses to undertake road projects in lagging districts.

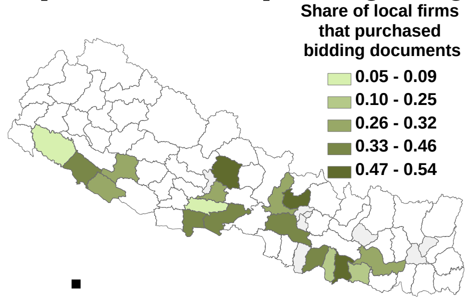
Public procurement can be used to foster the local business capacities. Particularly, public road works can contribute to local employment. In Latin America, large economies announced $25 billion of additional stimulus packages, mostly in the infrastructure sector, in 2008-2009. This is expected to create 2 million jobs or 7 percent of the unemployed in the region (Schwartz, Andres, and Dragoiu, 2009). In the United States, the labor requirement for a road project of equal value is much higher in the Southeast and South Central states, compared with other states (Anderson and Jacoby, 2000).

However, it is noteworthy that the existing literature is not necessarily in favor of preferential procurement. As per Marion (2007), road procurement costs under bid preferences are 3.8 percent higher in California. Citizens can benefit from local employment but may have to bear the heavier tax burden. Particularly, preferential treatments tend to be vulnerable to political interference. The favoritism toward local service providers, rather than lowest price contractors, is estimated to increase public procurement costs by 38 percent in Sweden (Hyytinen *et al*., 2006). Therefore, the strategic allocation of projects can be useful to foster the capability of local industries, but competitive pressure and transparency should be maintained in the procurement process.

Table 16. Average normalized bids by bidders' locality

	Obs	Mean	Std.Dev.	Min	Max
All bids	810	0.80	0.21	0.10	1.64
Local (project district) bids	313	0.82	0.20	0.29	1.14
Nonlocal bids	497	0.79	0.21	0.10	1.64

Figure 39. Proportion of local firms purchasing bidding documents



Security is great concern for not only procurement costs but also road management

Security issues were found to push up bid prices and discourage the market entry of potential firms. Both will end up with a heavy burden on the economy. Improved security would bring about multiple benefits for the public road procurement. First, improved security would bring down bid price, thereby government's procurement costs. As an indicative target, to reduce the procurement costs by 10 percent, security incidents need to be halved.[28] This cost savings can be interpreted as the increased confidence of contractors about project locations and general business environment. In addition, the improved security could induce more firms to participate in the competition, which would in turn contribute to reducing road procurement costs further.

Second, security incidence results in cost overruns and project delays. As an indicative target, to halve the project delays (as opposed to an average delay of 107 days), security incidents need to be halved. This would also mitigate cost overruns by some 15 percent of the overrun ratio.

Security issues would likely hamper road maintenance required, deteriorating the quality of roads. As an indicative target, for instance, to increase the average driving speed by 5 km per hour (some 20 percent of the average speed in our data), security incidents need to be more than halved. Our estimation results suggest that vehicles could drive 20 percent faster if the

[28] This is based on the estimated coefficient of ln*securitybefore* in the IV bid estimation.

number of security incidents would decline by 70 percent. This can be interpreted as the effect of the improved maintenance conditions around road locations.

Weather will cause project delays

The government should be aware of the risk of project delays caused by weather conditions. It rains a lot in Nepal. Increased precipitation is likely to cause project delays, which often result in cost overruns and undermine fiscal efficiency. The project risk related to weather is region-specific and clouded with uncertainty, as shown in Figure 9. Therefore, the road procurement planning and budget formulation need to have certain flexibility to incorporate possible project delays, with possible exogenous factors taken into account.

Our estimation results suggest that about 5 percent of project delays may need to be expected in the budget formulation and project preparation. This would allow to accommodate about 10-15 percent of unusual precipitation causing road project works. Too tight procurement plans will undermine the credibility and efficiency of the budget execution. If a project is implemented where it rains heavily, the government needs to be cautious about the budget formulation.

Proper and solid project design and preparation help to avoid unnecessary contract amendments and improve efficiency of the whole project cycle

Our evidence suggests that proper project specifications are important to avoid unnecessary contract amendments and minimize the risk of contractors' opportunistic behavior. Some work activities and inputs are found to be systematically prone to ex post contract amendments. Bitumen and earthworks are typical items that would cause cost overruns. Hence, it is important to design a project with proper technical specifications and make sure that all the information is reflected in the bidding documents.

Large projects should particularly be designed and prepared carefully. It is clear that large cost overruns and project delays tend to occur in World Bank projects, rather than government owned projects (Table 17). This is partly because World Bank projects are relatively large compared to Government projects. Larger projects are more likely to bring about large post-award contract adjustments, as discussed above.

The quality assurance mechanisms in procurement systems are important. As discussed, quality bidding documents need to be prepared with past procurement performance and exogenous factors, such as weather and conflicts, taken into account. In addition, the ex post quality evaluation needs to be implemented to exclude technically unreliable bids and bidders. In our sample, 10 percent of contracts did not have a post-qualification review before contract award. By tightening all these preparation and procurement processes, the reliability and efficiency in rural road project implementation can be improved as a whole.

Improved reliability and efficiency in project implementation will contribute to increase the budgetary performance in Nepal. In the country, the budget approval and release have been delayed in recent years. As the result, many road projects had to be launched at the end of the fiscal year. And delays would likely cause cost overruns, as discussed. The whole budgetary system turned out inefficient and unreliable.

Table 17. Average cost overruns and project delays in World Bank and Government projects

	Obs	Mean	Std. Dev.	Min	Max
Cost overruns (%)					
World Bank project	81	6.7	6.7	-1.5	21.7
Government project	74	0.3	3.4	-14.8	14.0
Project delays (days)					
World Bank project	81	190	256	-76	1217
Government project	74	12	37	-58	181

Roads are deteriorating with time, traffic and precipitation if not properly maintained

Our estimation results indicate that the quality of roads would decrease with the duration of use of roads, traffic volume and cumulative precipitation. If a road is used for one more month (some 5 percent of the average duration of road use in our sample), the probability of the road being rated to be "very uncomfortable" would increase by about 8 percent. Thus, the vast majority of roads would be rated to be "very uncomfortable" if they are used for more than one year. Security incidence would worsen the quality of roads, as discussed above. The poorly maintained road conditions will after all increase transport costs for the economy.

Capacity building for efficient road procurement is necessary at local level

Government effectiveness in contracting road contracts varies significantly across districts. Some can be attributed to technical reasons, such as technical complexity of projects. But there are significant unobserved (in)efficiency factors across districts (Figure 40). Some may be related to corruption. Others may be caused by more general reasons. Important, the lengthy contract award process is likely to result in significant project delays. Local government capacity needs to be developed further to speed up the bid evaluation process.

Improved procurement efficiency in donor financed projects will also help the government to procure road works efficiently. To award a road work, about 100 days are required in World Bank projects (Table 18). In DDC projects, it takes less than a month to conclude a contract after the bid opening. There are systematic differences in project specifications and required processes between the donor-assisted and government-financed projects. However, efforts toward reduce procurement inefficiency are needed for the government to enhance the procurement capacity and maximize value for money in the public projects. A recent analysis in Brazil shows that the duration of procurement processes for large public projects can be reduced by 24 days by simplifying the processes (Blancas *et al.*, 2011).

Figure 40. Unobserved district-specific inefficiency in contract awarding

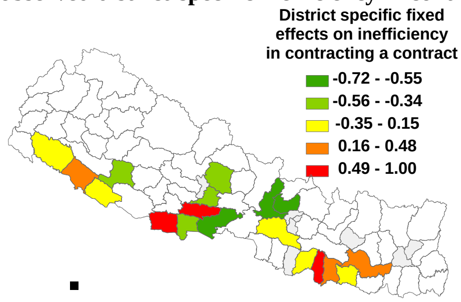


Table 18. Average time required to award a road contract after the bid opening (days)

	Obs	Mean	Std. Dev.	Min	Max
World Bank project	81	99.9	32.9	27	190
Government project	73	24.6	24.1	1	171

VI. CONCLUSION

Transport infrastructure is important for economic growth. In particular in rural areas, the lack of access to reliable transport infrastructure remains a significant constraint for people's daily life and local businesses. In Nepal, about 20 percent of rural residents have to spend more than 3 hours to go to the nearest marketplace or agriculture center. Over the world, about 900 million rural dwellers are estimated to have no access to all-weather road within two kilometers—typically equivalent to a walk of 20-25 minutes.

Public procurement is an important instrument to use resources wisely and efficiently. How to design an efficient procurement system is still a challenge in the infrastructure sector, because infrastructure projects are often technically complex, highly customized and politically sensitive. Therefore, the markets tend to be vulnerable to collusive bidding and corruption. The bid evaluation process tend to take long time. Contracts tend to be far from complete; many infrastructure projects undergo massive cost overruns and project delays. In addition, road assets will deteriorate quickly if not well maintained.

As a result, a series of policy challenges, from procurement design to contract management and project quality assurance, are interrelated to each other and need to be addressed in concert. New data were collected from 155 rural road upgrading contracts in Nepal, on which about 820 bids were submitted. Various important findings were discussed. However, in order to achieve the cost efficiency in public road procurement, competition is found the single most important factor. In addition, competition will prevent alleged collusion and corruption as well as foster local businesses.

To increase competition, it is essential to remove various entry barriers—both explicit and implicit ones. Public tender notices can be advertized more widely. Bidding documents can be distributed free of charge. E-procurement can be a good way to take these measures. It can also offer a one-stop service to publish all the information on business opportunities related to public works. In addition, e-procurement will be conducive to promoting accountability and transparency in public procurement systems. The capacity of local businesses also is also crucial to increase competition, because security issues are hampering the firms' participation in the market. Moreover, firms are found less willing to undertake public works far from their locations. Hence, local businesses are essential.

Enlarging contract packages may help to attract more potential bidders. But the government should be aware of the risk of increasing the bid evaluation costs. It takes longer to evaluate larger contracts. In addition, more firms are expected to apply. The efficiency in contract awarding seems to vary significantly across regions. To make the evaluation process short, capacity building may be necessary at the local level. This will also help to reduce the risk of collusion and corruption caused by the lengthy bid evaluation and contract award process.

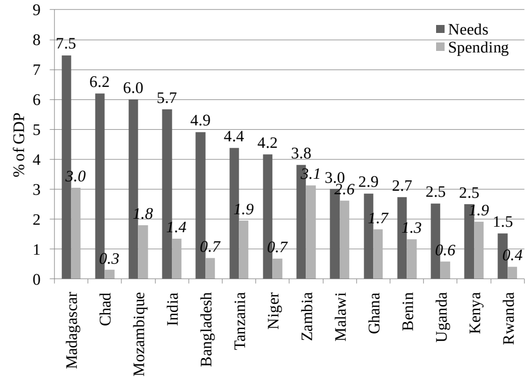
To mitigate cost overruns and project delays, security issues need to be addressed. Weather conditions are also one determinant. Particularly where it rains a lot, careful project and procurement planning is necessary. Otherwise, the efficiency of the budget execution will be undermined. Finally, roads deteriorate over time anyway. Traffic and precipitation will affect road conditions. However, security issues seem to be the most critical to implement timely routine road maintenance. Without proper maintenance, road assets would be depreciated quickly.

ANNEX I. ISSUES IN PUBLIC ROAD FINANCING

Good transport infrastructure is essential not only for people's life but also to increase the economy's efficiency in production and transaction. Better access to roads can help firms to minimize inventory and distribution costs (Shirley and Winston, 2004). Good road infrastructure can also attract foreign direct investment and increase exports (Cieślik and Ryan, 2004; Boudier-Bensebaa, 2005; Qureshi, 2008; World Bank, 2009b). Exporting firms generally prefer to be located close to motorways and accessibility to interregional demand (Holl, 2004).

However, available resources that can be used for infrastructure development are limited in many developing countries. Governments typically spend 1-3 percent of GDP for transport infrastructure. Low-income countries seem to invest on average 1.5 percent of GDP in the transport sector (Figure 41). In Bangladesh, about 0.7 percent of GDP of public resources are allocated to the transport sector. India is estimated to have been spending 1.4 percent of GDP for roads alone in recent years. Nepal spent $105 million or 1.2 percent of GDP for road development, of which 80 percent were supported by foreign aid (World Bank, 2005). These are often not sufficient compared to the remaining infrastructure deficits. The needs estimates vary across developing countries, ranging from 1.3 percent to 7.5 percent of GDP.

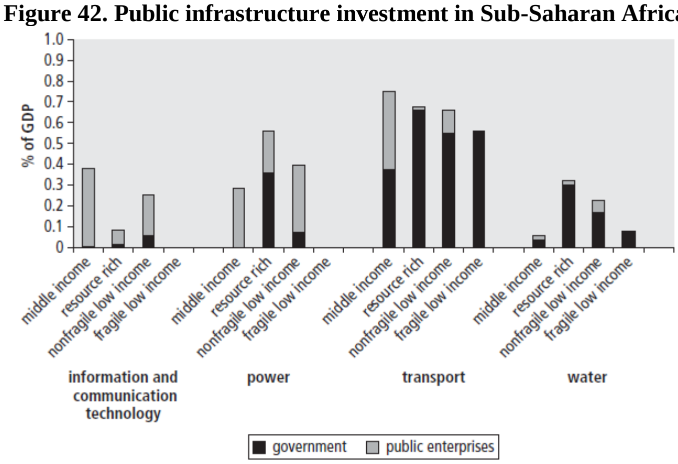
Figure 41. Transport infrastructure needs and spending in selected low-income countries



Sources: Briceno-Garmendia, Smits and Foster, 2008; Robin and Krishnamani, 2009; Bhattacharyay, 2010; Africa Infrastructure Country Diagnostic Database; Bangladesh Annual Development Program 2007/08; India 10th 5-Year Plan 2002-07.

The road sector particularly faces difficulties in ensuring financial sustainability. First, roads are de facto subsidized by governments, and the public finance remains a dominant source of funding in the transport sector (Figure 42). Except for a few cases, such as toll roads and cities adopting cordon pricing, roads are almost free of charge. Even in the United States, 277 toll roads, bridges and tunnels, totaling about 5,000 miles, account for only 0.2 percent of total road network, generating less than 10 percent of total highway funding required (NSTIFC 2009). Fuel levies and vehicle-related fees and taxes can partly finance public roads. But they are insufficient. Rather, fossil-fuel-related consumption is often heavily subsidized in developing countries. Energy subsidies in the developing world are estimated at \$312 billion in 2009 (IEA, 2010).

Figure 42. Public infrastructure investment in Sub-Saharan Africa

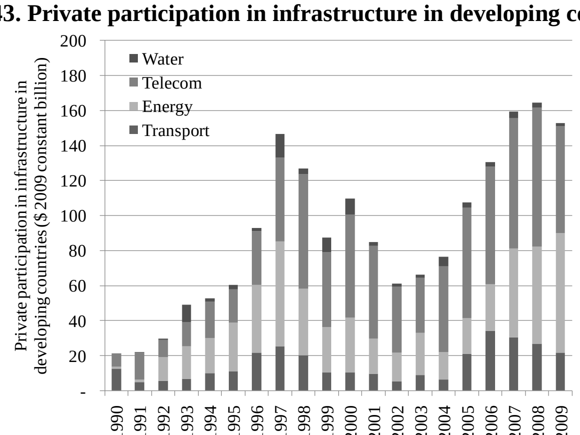


Source: Foster and Briceno-Garmendia, 2010.

Second, related to the above, private financing in transport infrastructure has been limited. Private participation in infrastructure continues to play an important role even in developing countries. It has reached close to $160 billion per annum in 2009. However, private participation remains selective by sector and country. The transport sector accounts for about 15 percent of total private investments in infrastructure for the past two decades. The vast majority were invested in the ICT and energy sectors (Figure 43).

It is noteworthy that private financing cannot substitute for public financing. Governments' strong commitment and other legal and institutional frameworks in the infrastructure sector are important to catalyze more private investments, as experienced in Latin America during the 1990s. While Chile and Colombia, in which public investment has remained high, attracted many private investments, private participation in infrastructure also tends to be marginalized, as in Argentina and Mexico where the public spending was also tightened under the fiscal pressure (Calderón and Servén, 2004; Fay and Morrison, 2007).

Figure 43. Private participation in infrastructure in developing countries



Source: PPI database.

However, the current public procurement systems may not work well to improve efficiency in spending resources in the infrastructure sector. Public procurement is normally sizeable in the economy. The public sector often account for 20 to 25 percent of GDP in developing countries. A large portion of this goes through public procurement systems (OECD, 2005c).

Thus, well-designed public procurement systems could save a lot of public resources. Conversely, a small flaw in the procurement design could result in significant losses of the economy.

It remains a challenge to design an efficient procurement system. Competition has been limited in infrastructure procurement auctions. In theory, competitive bidding is a powerful device that can induce potential contractors to reveal their true costs, thereby finding the lowest possible procurement price. However, the literature shows the average number of bidders is about 3 to 5 in infrastructure projects (Gupta, 2002; De Silva, Dunne, and Kosmopoulou, 2003; Alexeeva, Padam, and Queiroz, 2008).

Another concern is that infrastructure procurement is susceptible to corruption and collusion. The literature particularly points many alleged collusive cases in the road sector all over the world (e.g., Porter and Zona, 1993; Gupta, 2002; Price, 2008). This is because the size of road procurement markets is often significant. In addition, the market competition is repeated periodically. Thus, firms are easily motivated to collude with each other. Collusive arrangements can be sustained (e.g., Saijo *et al*., 1996; Thomas, 2005; Ware *et al*., 2007). Particularly in developing countries, the validity or enforceability of rules of conduct and other laws remains weak and the capability of detecting misconduct is far from perfect. In addition, sanctions may not be significant even if misconduct is detected.

In general, weak governance remains an important challenge to public procurement. This could possibly impose additional large costs on governments and thereby taxpayers. About 35 percent of firms are estimated to offer informal payment to public officials to secure public contracts in Africa; about 62 percent in Nepal (World Bank, 2009). In Indonesia construction materials for roads were stolen or misused during the project implementation, resulting in additional costs of 20 to 30 percent of total procurement costs (Olken, 2007). Auriol (2006) estimates the cost of corruption to be between 4 and 10 percent of world procurement spending. In Uganda, about 1.5 percent of GDP per year is estimated to be lost because of widespread corruption, mostly in public procurement (Mellemfolkeligt Samvirke, 2005). In Africa as a whole, one-fourth of GDP may be lost to corruption every year (Thachuk, 2005).

As a result, public roads are often underinvested and poorly maintained in developing countries. Road maintenance is particularly to be neglected. In Africa, about 30 percent of the infrastructure assets are estimated to need rehabilitation. In the road sector, only 37 percent of the road network in African low-income countries is in good condition. For feeder or rural roads, the share is even lower. 17 percent of the tertiary roads are in good condition (Foster and Briceno-Garmendia, 2010). Therefore, there remain the significant needs for road investment and maintenance that have not been met.

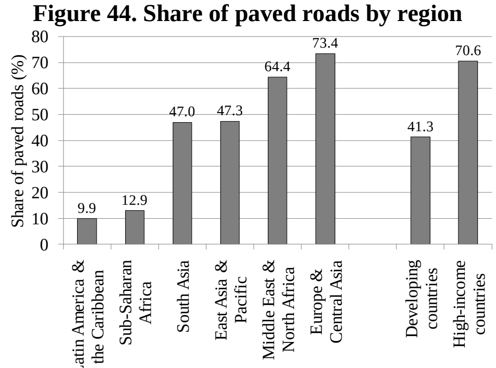
Important, road assets deteriorate exponentially without proper maintenance. According to a case study based on highway development software, HDM4, road roughness would increase over time and exceed a usual maintenance standard of IRI 4.5 in 5 to 6 years.[29] Generally, maintaining roads assets is more cost-effective than letting them deteriorated and reconstructing them. In Africa it is estimated that about $40 to $45 billion of road assets were lost because of inadequate maintenance, which would have cost only $12 billion, during the 1970s and 1980s (Harral and Faiz, 1988). Moreover, climate change may increase the importance of road maintenance, because poorly maintained roads are even more vulnerable to severe weather conditions. Potholes, clacks and wide joints are the places where water infiltrates in the road, accelerating deterioration. In developing countries, many roads remain to be paved (Figure 44). This could add to the risk of road deterioration and thus the cost of rehabilitating damaged road surfaces.

Therefore, the challenges for sustainable public road financing are complex and interrelated. Governance will affect not only the bidding behavior at competitive bidding but also post-

[29] In this particular case, a 10-km primary bituminous road with 2 lanes in a tropical area is examined using the software HDM4. The project life is assumed 35 years. The discount rate is set at 12 percent. Two maintenance options are compared: (i) do minimum (reconstruction when IRI reaches 10, with routine pothole patching and edge treatment), and (ii) GASO4.5 (structural overlay at IRI 4.5, with routine pothole patching and edge treatment).

award practices of contractors. Weather and other exogenous factors will also affect the bidding behavior, contractors' performance and the quality of roads delivered. All these issues need to be considered when evaluating the performance of public road procurement.

Figure 44. Share of paved roads by region



Source: World Development Indicators, accessed in March 2011.

Reference

Alexeeva, Victoria, Gouthami Padam, and Cesar Queiroz. 2008. "Monitoring Road Works Contracts and Unit Costs for Enhanced Governance in Sub-Saharan Africa." Transport Papers TP-21, World Bank, Washington, DC.

Anderson, WIllam, Arthur Jacoby. 2000. Measuring economic impacts of federal-aid highway projects. *Public Roads*, Vol. 64.

Athias, Laure, and Antonio Nuñez. 2006. "Number of Bidders and the Winner's Curse in Toll Road Concessions: An Empirical Analysis." CNI-Working Paper No. 2006-16, Center for Network Industries and Infrastructure, Berlin.

Blancas, Luis, Laura Chioda, Tito Cordella, Alexandre, Oliveira, Felix Vardy. 2011. Do procurement rules impact infrastructure investment efficiency? An empirical analysis of *Inversão das Fases* in São Paulo State. Policy Research Working Paper No. 5528, the World Bank.

Brannman, Lance, Douglass Klein and Leonard W. Weiss. 1987. "The Price Effects of Increased Competition in Auction Markets," *The Review of Economics and Statistics*, MIT Press, vol. 69(1), pages 24-32, February

De Silva, Dakshina, Timothy Dunne, and Georgia Kosmopoulou. 2003. "An Empirical Analysis of Entrant and Incumbent Bidding in Road Construction Auctions." *The Journal of Industrial Economics* 51: 295–316.

De Silva, Dakshina, Timothy Dunne, Anuruddha Kankanamge, and Georgia Kosmopoulou. 2008. “The Impact of Public Information on Bidding in Highway Procurement Auctions.” *European Economic Review* 52: 150–81.

Estache, Antonio, Atsushi Iimi. 2009. “Joint Bidding, Governance and Public Procurement Costs: A Case of Road Projects.” *Annals of Public and Cooperative Economics* 80: 393–429.

Estache, Antonio, Atsushi Iimi. 2010. “Bidder Asymmetry in Infrastructure Procurement: Are There Any Fringe Bidders?” *Review of Industrial Organization* 36: 136–87.

Estache, Antonio, Atsushi Iimi. 2011. *The Economics of Public Infrastructure Procurement in Developing Countries: Theory and Evidence.* Center of Economic Policy Research: London.

Fay, Marianne, and Tito Yepes. 2003. “Investing in Infrastructure: What Is Needed from 2000 to 2010?” Policy Research Working Paper No. 3102, World Bank, Washington, DC.

Flyvbjerg, Bent, Mette Skamris Holm, and Søren Buhl. 2002. “Underestimating Costs in Public Works Projects: Error or Lie?” *Journal of the American Planning Association* 68: 279-295.

Flyvbjerg, Bent, Mette Skamris Holm, Søren Buhl. 2004. What causes cost overrun in transport infrastructure project? *Transport Review*, Vol. 24, pp. 3-18.

Foster, Vivien, Cecilia Briceno-Garmendia. 2010. *Africa's Infrastructure: A Time for Transformation*. The World Bank.

Grimm, Veronika, Riccardo Pacini, Giancarlo Spagnolo, and Matteo Zanza. 2006. “Division into Lots and Competition in Procurement.” In *Handbook of Procurement*, ed. Nicola Dimitri, Gustavo Piga, and Giancarlo Spagnolo, 168–192. Cambridge University Press.

Guasch, Luis. 2004. *Granting and Renegotiating Infrastructure Concessions: Doing It Right*. Washington, DC: World Bank.

Gupta, Srabana. 2002. “Competition and Collusion in a Government Procurement Auction Market.” *Atlantic Economic Journal* 30: 13–25.

Haile, P. 2001. “Auctions with Resale Markets: An Application to U.S. Forest Service Timber Sales.” *The American Economic Review*, 91(3): 399-427.

Hong, Han and Matthew Shum. 2002. "Increasing Competition and the Winner's Curse: Evidence from Procurement," *Review of Economic Studies*, Blackwell Publishing, vol. 69(4), pages 871-98, October.

Hyytinen, Ari, Sofia Lundberg, Otto Toivanen. 2006. Favoritism in public procurement: Evidence from Sweden. *International Public Procurement Conference Proceedings*, September 2006, pp. 279-327.

Iimi, Atsushi. 2006. “Auction Reforms for Effective Official Development Assistance.” *Review of Industrial Organization* 28: 109-128.

Kagel, John H. and Dan Levin. 1986. "The Winner' s Curse and Public Information in Common Value Auctions." *American Economic Review*, December, 76(5), pp. 894-920.

Kessel, Reuben. 1971. "A Study of the Effects of Competition in the Tax-Exempt Bond Market." *The Journal of Political Economy* 79: 706–38.

Klemperer, Paul. 1998. Auctions with almost common values: The 'Wallet Game' and its applications**,"** *European Economic Review*, Elsevier, vol. 42(3-5), pages 757-769, May

Levin, Dan and James Smith. 1994. "Equilibirum Auctions with Entry", *The American Economic Review*, Vol. 84, No. 3. (Jun., 1994), pp. 585-599.

Li, Tong, and Isabelle Perrigne. 2003. "Timber Sale Auctions with Random Reserve Prices." *Review of Economics and Statistics* 85: 189–200.

Li, Tong, and Xiaoyong Zheng. 2006. "Entry and Competition Effects in First-Price Auctions: Theory and Evidence from Procurement Auctions. Cemmap working paper CWP13/06, University College London.

McAfee, Preston, and John McMillan. 1987. "Auctions with a Stochastic Number of Bidders." *Journal of Economic Theory* 43: 1–19.

Menezes Paulo K. and Flavio M. Menezes, 2000. "Auctions with endogenous participation," *Review of Economic Design*, Springer, vol. 5(1), pages 71-89.

Milgrom, Paul and Robert Weber. 1982. A Theory of Auctions and Competitive Bidding , *Econometrica*, 50, 1982, 1089-1122.

Nepal Central Bureau of Statistics. 2004. Nepal Living Standards Survey: Statistical Report. Nepal Central Bureau of Statistics.

Ohashi, Hiroshi. 2009. "Effects of Transparency in Procurement Practices on Government Expenditure: A Case Study of Municipal Public Works." *Review of Industrial Organization* 34: 26785.

Paarsch, Harry J. 1992. "Deciding between the common and private value paradigms in empirical models of auctions," *Journal of Econometrics*, Elsevier, vol. 51(1-2), pages 191-215

Paarsch, Harry J. 1997. "Deriving an Estimate of the Optimal Reserve Price: An Application to British Columbian Timber Sales." *Journal of Econometrics*, 78(2): 333-357.

Porter, Robert, and Douglas Zona. 1993. "Detection of Bid Rigging in Procurement Auctions." *Journal of Political Economy* 101: 518–38.

Price, Michael. 2008. "Using the Spatial Distribution of Bidders to Detect Collusion in the Marketplace: Evidence from Timber Auctions, *Journal of Regional Science* 48: 399-417.

Rezende, L. 2005. Auction econometrics with least squares. Mimeograph, University of Illinois, Urbana-Champlain, IL.

Schwartz, Jordan, Luis Andres, and Georgeta Dragoiu. 2009. “Crisis in Latin America: Infrastructure Investment, Employment and the Expectations of Stimulus.” Policy Research Working Paper No. 5009, World Bank, Washington, DC.

United Nations. 2011. Final Report: United Nations Development Assistance Framework for Nepal 2008-2010. Available at http://www.un.org.np/sites/default/files/report/united_nations_development_assistance_framework_2008-2010_-_evaluation_report.pdf

Ware, Glenn, Shaun Moss, Edgardo Campos, and Gregory Noone. 2007. “Corruption in Public Procurement: A Perennial Challenge.” In *The Many Faces of Corruption: Tracking Vulnerabilities at the Sector Level*, ed. Edgardo Campos and Sanjay Pradhan, 295–334. Washington, DC: World Bank.

Wilson, Robert. 1977. “A Bidding Model of Perfect Competition.” *The Review of Economic Studies* 44: 511–18.

Wolfstetter, Elmar. 1996. “Auctions: An Introduction.” *Journal of Economic Surveys* 10: 367–421.

World Bank. 2005a. Project Appraisal Document: Rural Access Improvement and Decentralization Project. Report No. 31624-NP. The World Bank.

World Bank. 2005b. *Infrastructure and the World Bank: A Progress Report*. World Bank: Washington, DC.

World Bank. 2007. Nepal Public Finance Management Review: Managing Public Finances for a New Nepal (No. 43384-NP).

World Bank. 2008a. *Procurement under World Bank-Financed Projects: FY07 Annual Report*. Operations Policy and Country Services. Washington, DC: World Bank.

World Bank. 2009. Project Paper on Nepal Rural Access Improvement and Decentralization Project, 2009 (No. 50766-NP).

World Bank. 2009. Enterprise Survey: 2009 Nepal. Available at http://www.enterprisesurveys.org/ExploreEconomies/?economyid=136&year=2009